NASA

Aeronautical Engineering
A Continuing Bibliography with Indexes

NASA SP-7037 (254)
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National Aeronautics and Space Administration

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NASA SP-7037(254)

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 254)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in June 1990 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*

NASA National Aeronautics and Space Administration
Office of Management
Scientific and Technical Information Division
Washington, DC 1990

This supplement is available from the National Technical Information Service (NTIS), Springfield, Virginia 22161, price code A08.

INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 538 reports, journal articles and other documents originally announced in June 1990 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA)*.

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals. The *IAA* items will precede the *STAR* items within each category.

Seven indexes -- subject, personal author, corporate source, foreign technology, contract number, report number, and accession number -- are included.

An annual cumulative index will be published.

Information on the availability of cited publications including addresses of organizations and NTIS price schedules is located at the back of this bibliography.

TABLE OF CONTENTS

TYPICAL REPORT CITATION AND ABSTRACT

NASA SPONSORED

ON MICROFICHE

ACCESSION NUMBER → N90-10834*# Old Dominion Univ., Norfolk, VA. Dept. of Mechanical Engineering and Mechanics. ← CORPORATE SOURCE

TITLE → **AN EXPERIMENTAL INVESTIGATION OF THE AERODYNAMIC CHARACTERISTICS OF SLANTED BASE OGIVE CYLINDERS USING MAGNETIC SUSPENSION TECHNOLOGY**

AUTHORS → CHARLES W. ALCORN and COLIN BRITCHER Nov. 1988 ← PUBLICATION DATE

90 p

CONTRACT NUMBER → (Contract NAG1-716) AVAILABILITY SOURCE

REPORT NUMBERS → (NASA-CR-181708; NAS 1.26:181708) Avail: NTIS HC A05/MF A01 ← PRICE CODE

COSATI CODE → CSCL 01/1

An experimental investigation is reported on slanted base ogive cylinders at zero incidence. The Mach number range is 0.05 to 0.3. All flow disturbances associated with wind tunnel supports are eliminated in this investigation by magnetically suspending the wind tunnel models. The sudden and drastic changes in the lift, pitching moment, and drag for a slight change in base slant angle are reported. Flow visualization with liquid crystals and oil is used to observe base flow patterns, which are responsible for the sudden changes in aerodynamic characteristics. Hysteretic effects in base flow pattern changes are present in this investigation and are reported. The effect of a wire support attachment on the 0 deg slanted base model is studied. Computational drag and transition location results using VSAERO and SANDRAG are presented and compared with experimental results. Base pressure measurements over the slanted bases are made with an onboard pressure transducer using remote data telemetry. Author

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

NASA SPONSORED

ON MICROFICHE

ACCESSION NUMBER → A90-13017*# Texas A&M Univ., College Station. ← CORPORATE SOURCE

TITLE → **IN-FLIGHT BOUNDARY-LAYER TRANSITION MEASUREMENTS ON A SWEPT WING**

AUTHORS → ANWAR AHMED (Texas A & M University, College Station), ← AUTHORS' AFFILIATION WILLIAM H. WENTZ (Wichita State University, KS), and R. NYENHUIS (Cessna Aircraft Co., Wichita, KS) Journal of Aircraft ← JOURNAL TITLE (ISSN 0021-8669), vol. 26, Nov. 1989, p. 979-985. refs.

CONTRACT NUMBER → (Contract NAG1-104)

Copyright

Flight tests were conducted at three different altitudes to detect transition on a smoothed test region of a swept-wing business jet wing using surface hot-film sensors and sublimating chemicals. Strong influence of sweep angle on transition location was observed when the aircraft was flown at some sideslip conditions to simulate changes in effective wing sweep angle. No effects of engine noise on transition were measured when different engine power settings were used. Flight instrumentation and ground data analysis techniques are described. Correlation was obtained between the hot-film sensor signals and sublimating chemicals for transition detection. Crossflow vortices were observed for one flight condition. Results of analyzed data for various flight-test conditions are presented. Author

AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 254)

JULY 1990

01

AERONAUTICS (GENERAL)

A90-28151

AHS, ANNUAL FORUM, 45TH, BOSTON, MA, MAY 22-24, 1989, PROCEEDINGS

Alexandria, VA, American Helicopter Society, 1989, 1095 p. For individual items see A90-28152 to A90-28235.

Copyright

Various papers on helicopters are presented. The general topics addressed include: dynamics, acoustics, manufacturing and product assurance, testing and evaluation, aerodynamics, advanced propulsion and icing, structures and materials, handling qualities, product support, aircraft design, avionics and systems, military operations. C.D.

A90-28163

MCDONNELL DOUGLAS HELICOPTER COMPANY FACTORY OF THE FUTURE PROJECT

THOMAS E. POINDEXTER (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 175-183.

Copyright

The strategy and implementation of the McDonnell Douglas Helicopter Company (MDHC) Factory of the Future (FoF) project is addressed. The implementation sequence of the FoF is outlined, including material tracking, automated ply cutting, midproject review, second site demonstration, composites fabrication, quality/nonconformance management, software configuration management, and hardware configuration management. The major issues to which MDHC will conform to the Integrated Composite Center (ICC) Program under contract with the USAF are pointed out. C.D.

A90-28164

ROTOR SMOOTHING EXPERT SYSTEM

PATRICK BENSON (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 185-189.

Copyright

The MDHC Rotor Smoothing Project was initiated to reduce the cost of the rotor smoothing (balancing) process. Costs are developed by several factors including flight time accrued during testing and inefficient smoothing causing high vibration related maintenance costs. An Expert System approach was used to solve the problem of lack of and/or extinction of flight line maintenance personnel experience. Once the Expert System has been developed, new techniques will be added to the system to improve its performance over the average maintenance personnel. A prototype PC-based Expert System has been developed as a result of the Rotor Smoothing Project. This prototype uses knowledge acquired from flight line maintenance personnel to reduce the time needed during the rotor smoothing task. Once a ground-based system is enlarged and proven, it will be possible to develop it into an onboard system for the Apache. Author

A90-28169

AIR-TO-AIR COMBAT TEST IV (AACT IV) AND THE AACT DATA BASE

DONALD SKRINJORICH and G. THOMAS WHITE (U.S. Army, Aviation Applied Technology Directorate, Fort Eustis, VA) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 235-242.

Copyright

The U.S. Army Aviation Applied Technology Directorate (AATD) has conducted one-on-one Air-to-Air Combat Tests (AACT) during the period of April 1983 to April 1987. Various Army fleet helicopters, as well as other selected 'state-of-the-art' helicopters, have been placed in an environment designed to simulate air-to-air combat engagements that would result in gunnery encounters between two helicopters at close range. These tests have been performed at the Naval Air Test Center (NATC) to evaluate maneuverability and agility issues and to establish an engineering data base consisting of both fixed forward and turreted gun configured aircraft starting from prescribed initial flight conditions and then allowed to maneuver freely to 'defeat' the opposing aircraft. The data base contains basic aircraft state, performance, and structural loads data. This paper is offered as an introduction and description of the AACT data base which can, and is currently being used to study many areas of rotorcraft air-to-air enhancement. A number of findings and recommendations gleaned from the AACT program are also presented. Author

A90-28242

THE REVOLUTION CONTINUOUS

VOLKER VON TEIN (MBB GmbH, Munich, Federal Republic of Germany) AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Paper. 28 p.

(MBB-UD-557-89-PUB) Copyright

A short review of evolutionary helicopter development is presented with particular emphasis on the European industry. Diverse developmental programs such as the advanced light twin helicopter, the future Franco/German attack helicopter, the NATO helicopter of the 90s, and the Indian advanced light helicopter are discussed. Experimental programs such as the bearingless rotor, the FEL rotor, the IDS rotor, composite airframes, the use of composites, fly-by-light technology, avionics and advanced cockpits, and advanced weapon systems are noted. It is concluded that, in order for the helicopter industry to develop further in both the civil and military areas, it will be essential to develop more intense cooperation between manufacturers. R.E.P.

A90-28319

THE TWO LEVEL MAINTENANCE - I LEVEL DILEMMA

STUART KORNREICH (M & T Co., Philadelphia, PA) IN: AUTOTESTCON '89 - IEEE International Automatic Testing Conference, Philadelphia, PA, Sept. 25-28, 1989, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 63-66.

Copyright

Previous attempts at implementing the two-level maintenance philosophy for Navy aircraft did not prove to be workable, and an 'AI' level capability was added at a later stage in at least one major program. In this work, an attempt is made to define the real requirements for a workable two-level system, and some actual cases of what is being done today on some major weapon systems in the Navy are shown. Recommendations on how to implement and test for a working weapon system BIT/BITE (built-in-test/ built-in-test equipment) are offered along with some criteria to measure success. Additionally, related issues such as design for testability and repair capability are addressed since these items can easily take a back seat or be omitted entirely when driving hard to a two-level maintenance concept. I.E.

A90-28348
AUXILIARY POWER UNIT MAINTENANCE AID - FLIGHT LINE ENGINE DIAGNOSTICS
PATRICIA M. MCCOWN, TIMOTHY J. CONWAY, and CHERYL VENTURA CONWAY (Allied-Signal Aerospace Co., Bendix Test Systems Div., Teterboro, NJ) IN: AUTOTESTCON '89 - IEEE International Automatic Testing Conference, Philadelphia, PA, Sept. 25-28, 1989, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 296-301.
Copyright

The auxiliary power unit maintenance aid (APU Maid) is designed to satisfy APU maintenance requirements for forward area maintenance onboard the aircraft, at the flight line, and in the shop. APU Maid is initially being demonstrated on flight line hardware. The maintenance environment includes among its components an artificial intelligence (AI) based diagnostic system, an automated technical information system, and a maintenance management system. The diagnostic system is built on a core of diagnostic knowledge sources that include an event-based system functional model, a structural model, symptom/fault information, and a wide range of logistics data. This core diagnostic model is designed for generic application to any electromechanical system including engines, flight controls, landing gears, and transmissions. It can also be applied to electronic systems, including avionics. The project objective is described, and the APU Maid components are described in detail. I.E.

A90-29598*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EXPERIMENTAL AEROELASTICITY - HISTORY, STATUS AND FUTURE IN BRIEF
RODNEY H. RICKETTS (NASA, Langley Research Center, Hampton, VA) AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990. 13 p. refs
(AIAA PAPER 90-0978) Copyright

The National Aeronautics and Space Administration (NASA) conducts wind-tunnel experiments to determine and understand the aerolastic characteristics of new and advanced flight vehicles, including fixed-wing, rotary-wing, and space-launch configurations. Review and assessments are made of the state-of-the-art in experimental aeroelasticity regarding available facilities, measurement techniques, and other means and devices useful in testing. In addition, some past experimental programs are described which assisted in the development of new technology, validated new analysis codes, or provided needed information for clearing flight envelopes of unwanted aeroelastic response. Finally, needs and requirements for advances and improvements in testing capabilities for future experimental research and development programs are described. Author

A90-29637
GLASSY WATERS FOR SEASTAR
IAN PARKER Aerospace Composites and Materials (ISSN 0954-5832), vol. 2, Mar.-Apr. 1990, p. 6-8.
Copyright

The intrinsic resistance to seawater corrosion of glass fiber-reinforced polymer-matrix composites will be exploited by the recently developed 'Seastar' turboprop-engined amphibious aircraft. Glass fiber reinforcement is not only more economical than the carbon and aramid fiber alternatives, but furnishes the superior damage tolerance made necessary by high speed impacts from waterborne debris during takeoffs and landings. The Seastar airframe is produced by a two-stage curing process in which smaller components are defined by the first cycle and larger ones are formed by cocuring the assembled components in the second cycle. Seastar can carry 12 passengers. O.C.

A90-29641
THE CHALLENGE OF LHX
FRANK COLUCCI Aerospace Composites and Materials (ISSN 0954-5832), vol. 2, Mar.-Apr. 1990, p. 28, 29, 31-33.
Copyright

The primary contractor for the next-generation LHX combat helicopter for the U.S. Army has projected that its airframe and rotor system, in view of weight minimization criteria, will be made up of composite materials to the extent of 90 percent of total weight. The manufacturer is intensely concerned with the optimization of such materials' composition to achieve the greatest economies consistent with performance specifications. The high production rate manufacture of such a composite airframe has presented major engineering challenges, which have been addressed by wholesale use of CAD techniques. The effects of composites' use on battle damage tolerance and radar signature minimization are discussed. O.C.

A90-29892
COMPOSITE CERTIFICATION FOR COMMERCIAL AIRCRAFT
Aerospace Engineering (ISSN 0736-2536), vol. 10, April 1990, p. 29-32.
Copyright

FAA regulations dealing with the use of composites in structural applications are discussed. The proof of structure is divided into three major areas of certification: static, fatigue/damage tolerance, and flutter. Three levels of testing, the material property level, material interaction level, and component/full scale level, are covered. The importance of in-process inspection of composite operations is emphasized. V.T.

A90-29921
AERODYNAMIC, THERMAL AND MECHANICAL PROBLEMS IN THE AEROSPACE FIELD [PROBLEMES D'AERODYNAMIQUE DE THERMIQUE ET DE MECANIQUE DANS LE DOMAINE AEROSPATIAL]
J. CARPENTIER (ONERA, Chatillon-sous-Bagneux, France) Revue Francaise de Mecanique (ISSN 0373-6601), no. 4, 1989, p. 365-379. In French.
Copyright

The potential of numerical and experimental studies in the area of aerodynamic and aerothermodynamics is evaluated. It is noted that beyond the pure scientific calculations required to achieve successful advanced designs for new aircraft, helicopters, missiles, space launchers, and hypersonic reentry vehicles, constant evaluation must be made of continuing technological developments and the consequent unavoidable delays that must be taken into account. Available test facilities required for these advanced projects are described. Finally, the aspects of international cooperation and the structure of European collaboration with regard to research facilities is examined together with the experimental test facilities of ONERA. These include two pressurized subsonic wind tunnels located at the Modane-Avrieux and Fauga-Mauzac centers, a cryogenic transonic wind tunnel at Toulouse, and a hypersonic flow (Mach 10) wind tunnel at Chalais-Meudon. Some new concepts in propulsion systems are mentioned. R.E.P.

A90-30114
EMERGING NEW TECHNOLOGIES AT SIKORSKY AIRCRAFT
RAJARAMA K. SHENOY (Sikorsky Aircraft, Stratford, CT) Vertiflite (ISSN 0042-4455), vol. 36, Mar.-Apr. 1990, p. 7-11.
Copyright

Four technology areas are reviewed: expert systems (ES), artificial intelligence (AI), advanced simulation, and engineering automation. Sikorsky Aircraft is utilizing ES and AI technologies to develop systems for diagnostics, maintenance, mission planning, and simulation. Such systems as the engine diagnostic expert program (HELIX) and the portable maintenance aid (PMA) systems have been developed using the ES and AI technology. The simulation technology, which makes the design cycle less expensive and shorter, has been used to develop modeling of the mission equipment package (MEP) and of the tactical environment. A new engineering automation system, IGOR, accommodates the complex task of facilitating and exchanging information from the central information file. Several emerging technology areas are suggested. N.B.

A90-30760#

ROBOTICS FOR FLIGHTLINE SERVICING

MANGAL D. CHAWLA and SAMUEL E. HAGINS (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 1126-1129.

This paper examines the feasibility of using robotics on the flight line. The objective is to develop the capabilities and technologies to perform aircraft ground-support functions more efficiently using fewer personnel. This could enhance future sortie-generation capabilities by assisting ground crews in the preparation of mission-ready aircraft. The proposed system would also encompass many types of fighters and transports in the USAF inventory and consider both fixed-hangar and bare-base scenarios. Ground refueling using aerial refueling tactics was selected as the initial turnaround candidate because of its frequency, impact on sortie generation, availability of hardware, and the fact that in-flight refueling receptacles are standard equipment on all tactical and strategic aircraft. This makes refueling ideal for robotics. I.E.

A90-30768#

THE IMIS F-16 INTERACTIVE DIAGNOSTIC DEMONSTRATION

WILLIAM R. LINK (USAF, Human Resources Laboratory, Wright-Patterson AFB, OH) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 1359-1362.

The design and operation of an integrated maintenance information system (IMIS) are discussed. The IMIS allows a hand-held computer to be plugged into an aircraft, perform built-in-tests, read and analyze the fault data on the data-transfer unit, provide diagnostic advice, and present automated technical procedures. An interactive diagnostic demonstration on an F-16 is scheduled for Homestead AFB, Florida, in early 1989. I.E.

A90-30809

LOGISTICS SUPPORT PLANNING FOR STANDARDIZED AVIONICS

JEFFREY L. BROOKS and MICHAEL G. WALLACE (SLI Avionic Systems Corp., Grand Rapids, MI) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 4. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 1929-1936. refs

Copyright

An overview of the Standard Flight Data Recorder (SFDR) program is presented. The SFDR is a multifunction, crash-survivable, solid-state flight data recorder which gathers incident, structural fatigue, engine performance, individual aircraft tracking, and maintenance diagnostics data. The SFDR is in the process of being applied as Government Furnished Equipment (GFE) across the USAF and Navy aircraft fleets. The authors describe how the challenge of developing an acquisition strategy and integration concept has been addressed, and they focus on the integrated logistics support plan for the GFE program, involving the many USAF logistics centers and USN aviation depots responsible for the wide range of fixed- and rotary-wing aircraft to receive the SFDR system. I.E.

A90-31247#

SUKHOI AND GULFSTREAM GO SUPERSONIC

RICHARD DEMEIS Aerospace America (ISSN 0740-722X), vol. 28, April 1990, p. 40-42.

Copyright

A Soviet-American cooperative program to develop a supersonic business jet is described. The program, between Gulfstream Aerospace and the Sukhoi Design Bureau, is intended to develop a supersonic jet with a cruise speed of Mach 2.0, a tailored aircraft shape, and a size and weight that are smaller than current supersonic transports. It is suggested that the final design will produce lesser shock waves and sonic booms than previous supersonic jets. The configuration proposed by the Sukhoi Design Bureau, which is 114-ft long with an arrow-shaped 56-ft wing span, is described and illustrated. R.B.

02

AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

A90-27947

BOUNDARY ELEMENT SOLUTION OF THE TRANSONIC INTEGRO-DIFFERENTIAL EQUATION

W. OGANA (Nairobi, University, Kenya) Engineering Analysis with Boundary Elements (ISSN 0955-7997), vol. 6, Dec. 1989, p. 170-179. refs

Copyright

The transonic integro-differential equation for two-dimensional flows is solved by boundary element methods. In addition to constant and quadrilateral elements, hybrid elements based on constant elements in the streamwise direction and variable elements in the transverse direction are developed. Computation is carried out for parabolic-arc and NACA0012 airfoils, and the results, which converge fast, compare favorably with finite-difference solutions. The hybrid elements are to be preferred because they yield results which are more accurate than constant elements, without the computational complexity associated with quadrilateral elements. Moreover, they can be applied with a small number of nodes by using only one strip of rectangular elements. Author

A90-27966*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

ANALYSIS OF FULLY STALLED COMPRESSOR

WOJCIECH ROSTAFINSKI (NASA, Lewis Research Center, Cleveland, OH) Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, Mar.-Apr. 1990, p. 177-180. Previously cited in issue 17, p. 2470, Accession no. A86-38480. refs

A90-27976#

NEWTONIAN FLOW OVER OSCILLATING TWO-DIMENSIONAL AIRFOILS AT MODERATE OR LARGE INCIDENCE

HAMDI T. HEMDAN (King Saud University, Riyadh, Saudi Arabia) AIAA Journal (ISSN 0001-1452), vol. 28, April 1990, p. 577-583. refs

Copyright

This paper considers the problem of pitching oscillating sharp-edged, two-dimensional thin airfoils in Newtonian flow at moderate or large angles of attack. By extending and perturbing the steady flow solution past the compression surface of such airfoils, simple formulas for the unsteady surface pressure and the aerodynamic derivative are found. It is shown that moderate angles of attack have a destabilizing effect for certain pivoting positions, which increases with increasing concavity. On the other hand, pitching oscillations of concave or convex airfoils at large angles of attack are always dynamically stable. Author

A90-27977*# Notre Dame Univ., IN.
MEASUREMENTS IN A SEPARATION BUBBLE ON AN AIRFOIL USING LASER VELOCIMETRY
EDWARD J. FITZGERALD and THOMAS J. MUELLER (Notre Dame, University, IN) AIAA Journal (ISSN 0001-1452), vol. 28, April 1990, p. 584-592. Research supported by the University of Notre Dame. refs
(Contract NSG-1419)
Copyright
An experimental investigation was conducted to measure the reverse flow within the transitional separation bubble that forms on an airfoil at low Reynolds numbers. Measurements were used to determine the effect of the reverse flow on integrated boundary-layer parameters often used to model the bubble. Velocity profile data were obtained on an NACA 663-018 airfoil at angle of attack of 12 deg and a chord Reynolds number of 140,000 using laser Doppler and single-sensor hot-wire anemometry. A new correlation is proposed based on zero velocity position, since the Schmidt (1986) correlations fail in the turbulent portion of the bubble. Author

A90-27979#
CALCULATION OF TRANSONIC FLOWS WITH SEPARATION PAST ARBITRARY INLETS AT INCIDENCE
ARVIN SHMILOVICH (Douglas Aircraft Co., Long Beach, CA) AIAA Journal (ISSN 0001-1452), vol. 28, April 1990, p. 601-609. Previously cited in issue 07, p. 941, Accession no. A88-22532. refs
Copyright

A90-27985*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
EXPERIMENTAL STUDY OF NONSTEADY ASYMMETRIC FLOW AROUND AN OGIVE-CYLINDER AT INCIDENCE
D. DEGANI and G. G. ZILLIAC (NASA, Ames Research Center, Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 28, April 1990, p. 642-649. Previously cited in issue 21, p. 3482, Accession no. A88-50579. refs
Copyright

A90-28171
EFFICIENT FREE WAKE CALCULATIONS USING ANALYTICAL/NUMERICAL MATCHING AND FAR-FIELD LINEARIZATION
DONALD B. BLISS (Duke University, Durham, NC) and WAYNE O. MILLER IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 253-263. Research sponsored by the U.S. Army. refs
Copyright
A hybrid analytical and numerical method called Analytical/Numerical Matching (ANM) is used here to calculate the velocity field of rotor wake vortex filaments. This approach is found to give accuracy comparable to the best available curved element methods with greatly reduced computer time. Sample calculations are presented for vortex rings and for rotor wakes. Because ANM is functionally simple, it is possible to linearize all or part of the free wake calculation, thereby avoiding large numbers of repetitive Biot-Savart law calculations. The time-marching solution procedure for a linearized free wake is described and sample results are given. C.D.

A90-28172
IDENTIFICATION OF RETREATING BLADE STALL MECHANISMS USING FLIGHT TEST PRESSURE MEASUREMENTS
N. C. G. ISAACS and R. J. HARRISON (Westland Helicopters, Ltd., Yeovil, England) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 265-279. Research supported by the Ministry of Defence Procurement Executive. refs
Copyright
The results of a flight trial carried out using an extensively pressure plotted British Experimental Rotor Programme (BERP) rotor are presented. The primary purpose of the trial was to identify the detailed flow mechanisms involved in retreating blade stall flutter on the full scale BERP rotor in flight. It is shown that the rotor behaves in accordance with its original design aims and that features of the blade behavior seen in static wind tunnel tests are observed in flight. Trailing edge pressure measurements are used to determine local stall patches which provide valuable insight into retreating blade stall behavior. A method has been developed to corect errors in these measurementts which can mask the regions of trailing edge separation used to identify the stall patches. Comparisons are made between predicted stall patches and blade control loads and flight data at the retreating blade limit, and are shown to be in excellent agreement. Author

A90-28174
BELLTECH - A MULTIPURPOSE NAVIER-STOKES CODE FOR ROTOR BLADE AND FIXED WING CONFIGURATIONS
JOHN B. MALONE and J. C. NARRAMORE (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 297-310. Research supported by Cray Research, Inc. refs
Copyright
An existing three-dimensional Navier Stokes solution procedure, originally developed for the aerodynamic analysis of helicopter rotor blades, has been modified to provide for the analysis of fixed wing configuratons as well. The original rotor blade procedure is described and the modifications required to switch from rotor blade to fixed wing calculations are discussed. Sample computations are presented for a transport wing model operating at subcritical and supercritical free stream conditions and for a modern rotor configuration in forward flight. Author

A90-28176
PREDICTION AND MEASUREMENT OF THE AERODYNAMIC INTERACTIONS BETWEEN A ROTOR AND AIRFRAME IN FORWARD FLIGHT
NARAYANAN KOMERATH, HOWARD MCMAHON, ALBERT BRAND, SHIUH-GUANG LIOU, and DIMITRIS MAVRIS (Georgia Institute of Technology, Atlanta) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 323-335. refs
(Contract DAAG29-82-K-0084)
Copyright
Results of a detailed study of aerodynamic interactions are summarized. The test case is a two-bladed, rigid teetering rotor above a hemisphere-cylinder airframe in low-speed forward flight. A multi-faceted set of measurements, including surface pressures, thrust, flow velocity, and vortex trajectories has been acquired and used to develop and validate a potential-flow method to predict such interactions. The salient features of the measurements and the prediction method are summarized. The test case shows strong interaction effects. The interaction problem is seen to be dominated by unsteady, but mostly periodic, effects. The potential flow method is seen to be capable of predicting the dominant features of the interaction, in an azimuth-resolved fashion, under these conditions. However, it is inadequate to explain the details of the interaction of the strong vortices from the rotor with the airframe surface. Author

A90-28194* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
A NUMERICAL ANALYSIS OF THE BRITISH EXPERIMENTAL ROTOR PROGRAM BLADE
EARL P. N. DUQUE (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 523-532. refs
Copyright
Two Computational Fluid Dynamic codes which solve the compressible full-potential and the Reynolds-Averaged Thin-Layer

Navier-Stokes equations were used to analyze the nonrotating aerodynamic characteristics of the British Experimental Rotor Program (BERP) helicopter blade at three flow regimes: low angle of attack, high angle of attack and transonic. Excellent agreement was found between the numerical results and experiment. In the low angle of attack regime, the BERP had less induced drag than a comparable aspect ratio rectangular planform wing. At high angle of attack, the blade attained high-lift by maintaining attached flow at the outermost spanwise locations. In the transonic regime, the BERP design reduces the shock strength at the outer spanwise locations which affects wave drag and shock-induced separation. Overall, the BERP blade exhibited many favorable aerodynamic characteristics in comparison to conventional helicopter rotor blades. Author

A90-28195* Georgia Inst. of Tech., Atlanta.
COMPARISON OF MEASURED INDUCED VELOCITIES WITH RESULTS FROM A CLOSED-FORM FINITE STATE WAKE MODEL IN FORWARD FLIGHT
DAVID A. PETERS and CHENG JIAN HE (Georgia Institute of Technology, Atlanta) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 533-550. Research sponsored by the U.S. Army. refs
(Contract NAG2-462)
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An unsteady, three-dimensional induced-flow model is applied to compute the induced-flow distribution of a rotor in forward flight, and numerical results are compared against LDV measurements for both time-averaged and unsteady induced flow at the disk. The former flow shows good agreement with measured data, except just behind the pylon at the lowest advanced ratio and near the blade tips for rectangular blades at high advance ratios. The method performs as well or better than other codes that have been applied to these data, takes less computing time, and is better suited to aeroelastic analysis. Results with only four harmonics and 15 state variables converge to all fundamental characteristics of the time-averaged flow. C.D.

A90-28197* Woodside Summit Group, Inc., Mountain View, CA.
ADVANCED ROTOR COMPUTATIONS WITH A CORRECTED POTENTIAL METHOD
JOHN O. BRIDGEMAN (Woodside Summit Group, Inc., Mountain View, CA), ROGER C. STRAWN, FRANCIS X. CARADONNA (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA), and CHING S. CHEN (NASA, Ames Research Center, Moffett Field, CA) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 563-577. refs
Copyright
An unsteady Full-Potential Rotor code (FPR) has been enhanced with modifications directed at improving its drag prediction capability. The potential code has been rewritten with modifications to increase the code accuracy. Also, the shock generated entropy has been included to provide solutions comparable to the Euler equations. Two different weakly interacted boundary layer models have also been coupled to FPR in order to estimate skin-friction drag. One is a two-dimensional integral method and the other is a three-dimensional finite-difference scheme. The new flow solver is able to find accurate inviscid drags without recourse to numerical error tares. This permits the resolution of drag distributions resulting from rotor geometric variations. Good comparisons have been obtained between computed and measured torque for a rectangular and a highly swept model rotor. Author

A90-28198
INVESTIGATION OF AERODYNAMIC INTERACTIONS BETWEEN A ROTOR AND FUSELAGE IN FORWARD FLIGHT
J. G. LEISHMAN, N. BI, D. K. SAMAK, and M. GREEN (Maryland, University, College Park) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 591-601. refs
(Contract DAAL03-88-C-0002)
Copyright
The first results are described from a new experiment designed systematically to investigate interactional aerodynamic problems which exist between the various components of a helicopter. The results indicate that, while the rotor wake produces large changes in the mean loads on the fuselage, unsteady pressure fluctuations due to blade passage and wake impingement are the dominant form of loading. The magnitude of the unsteady loads on the fuselage is primarily a function of rotor thrust. When operating at low advance ratio, the presence of the fuselage produces an increase in rotor thrust for a given collective pitch and a reduction in rotor power for a given thrust. The wake skew angle is an effective parameter governing the magnitude of the time-averaged interactional loads on both the rotor and fuselage. C.D.

A90-28228* Georgia Inst. of Tech., Atlanta.
THE EFFECT OF AN UNSTEADY THREE-DIMENSIONAL WAKE ON ELASTIC BLADE-FLAPPING EIGENVALUES IN HOVER
DAVID A. PETERS and AY SU (Georgia Institute of Technology, Atlanta) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 999-1015. Research sponsored by the U.S. Army. refs
(Contract NAG2-462)
Copyright
This paper describes the formulation of a finite-state inflow model based on an acceleration potential and a helical wake geometry. The states of the model are coefficients of an inflow expansion in terms of a Fourier series (azimuthally) and of special polynomials (radially). The integrals over the wake are done in closed-form to obtain a set of ordinary differential equations for the inflow coefficients. The forcing functions for these equations are generalized forces which are integrals of the blade loading exactly as in structural dynamics. This model implicitly includes (for the hover case) Prandtl-Goldstein tip losses, dynamic inflow, and Theodorsen/Loewy lift deficiency. Thus, it is a fully three-dimensional unsteady wake model. Here, this model is coupled with elastic-blade equations in hover and eigenvalues are found. The results show that the three-dimensional wake has a large effect on the flap damping of all modes. Author

A90-28241
AERODYNAMIC DESIGN OF THE V-22 OSPREY PROPROTOR
MICHAEL K. FARRELL (Bell Helicopter Textron, Inc., Fort Worth, TX) AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Paper. 14 p. refs
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This paper describes the aerodynamic design of the V-22 Osprey proprotor in terms of design objectives, design parameters, and design verification. During the development of the proprotor, the three design objectives were a hover figure of merit of 0.8, a propulsive efficiency of 0.8, and a maximum proprotor blade loading of 0.4. Based on these design objectives and in conjuncton with performance, operational, and service constraints, the diameter, number of blades, tip speed, airfoil, twist, chord, taper ratio, and spinner configuration were selected. These design parameters were verified by means of numerous small and large scale model tests. Author

A90-28243
CIRCULATION CONTROL TAIL BOOM AERODYNAMIC PREDICTION AND VALIDATION
HORMOZ TADGHIGHI and THOMAS L. THOMPSON (McDonnell Douglas Helicopter Co., Mesa, AZ) AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Paper. 12 p. refs
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A new theoretical representation of circulation control aerodynamics based on a two-dimensional discrete vortex modeling technique is described in this paper. The basic idea of the method is to replace the shear layer by a series of discrete vortex filaments surrounded by an irrotational, non-viscous flow field. The method basically requires that the initial flow field be represented by

potential flow elements (e.g. doublets, sources, and sinks). In order to predict accurately the drag, a boundary layer model based on discrete vortices and doublets has been implemented. The present model can be applied to circular as well as elliptical sections. The model's application has been extended to a three-dimensional circulation control problem by introducing a prescribed jet strength distribution in the method. Finally, the model's predictions have been compared with experimental data for circular and elliptic sections. Author

A90-28252

MEASUREMENTS, VISUALIZATION AND INTERPRETATION OF 3-D FLOWS - APPLICATION WITHIN BASE FLOWS

C. BERNER and P. WEY (Saint-Louis, Institut Franco-Allemand de Recherches, France) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 1-11. refs

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Experimental investigations of the flow field in the near-wake of axisymmetric afterbodies at an angle of attack of 5 deg are presented. Models consist of a cylindrical afterbody and a conical boat-tail. Measurements were performed by means of a three-dimensional frequency-shifted laser Doppler velocimeter (LDV) at a freestream Mach number of 0.5. Results include wall static pressure distributions over the afterbody and on the base, mean velocities, and the corresponding velocity fluctuations. The results show that the LDV is a useful tool to provide well-documented information of complex flow fields of an axisymmetric or three-dimensional nature for confrontation between theory and experience. Several approaches to the display and interpretation of the large amount of data obtained are presented. A fast and efficient algorithm for the visualization of three-dimensional scalar data fields is presented; it can realistically reconstruct and display contour surfaces. I.E.

A90-28552

AERODYNAMICS OF HUMAN-POWERED FLIGHT

MARK DRELA (MIT, Cambridge, MA) IN: Annual review of fluid mechanics. Volume 22. Palo Alto, CA, Annual Reviews, Inc., 1990, p. 93-110. Research supported by MIT. refs

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A historical perspective on human-powered aircraft (HPA) is presented. The performance of the human engine that sets the aerodynamic requirements of HPAs in perspective is then examined. A review of HPA wing aerodynamics covers historical overview and basic requirements, structural considerations, maneuvering yaw and roll effects on airloads, and dominance of damping. Airfoils and propellers for HPAs are also examined. It is concluded that advances in the aerodynamics of HPAs were made possible by improved analysis tools, improved structural and manufacturing technology, and aerodynamic improvements that permit a human being to sustain himself in the air for many hours with only his physical effort. R.E.P.

A90-28555* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

AEROTHERMODYNAMICS AND TRANSITION IN HIGH-SPEED WIND TUNNELS AT NASA LANGLEY

I. E. BECKWITH and C. G. MILLER, III (NASA, Langley Research Center, Hampton, VA) IN: Annual review of fluid mechanics. Volume 22. Palo Alto, CA, Annual Reviews, Inc., 1990, p. 419-439. refs

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The evolutionary development of subsonic, supersonic, and hypersonic wind tunnels for the study of aerodynamic, aerothermodynamic, and fluid-dynamic characteristics of the flow about models, including transition from laminar to turbulent boundary layers, is discussed. Currently, three supersonic and seven hypersonic wind tunnels are operational at Langley, and two additional tunnels are scheduled to become operational by 1990. In the present work, an effort is made to provide a 'tour'of selected supersonic and hypersonic wind tunnels at NASA-Langley used for aerodynamic and aerothermodynamic testing of models, and to present the evolution of quiet-tunnel technology at this facility over the last decade. It is noted that upgrades to the hypersonic facilities complex are underway in order to provide the high flow quality and improved data accuracy required to calibrate advanced computational fluid-dynamic computer codes. Also to be provided are increased productivity required for configuration development and improved reliability to support major hypersonic programs in an efficient and timely manner. R.E.P.

A90-28979

USING THE METHOD OF SYMMETRIC SINGULARITIES FOR CALCULATING FLOW PAST SUBSONIC FLIGHT VEHICLES [PRIMENENIE METODA SIMMETRICHNYKH OSOBENNOSTEI DLIA RASCHETA OBTEKANIIA DOZVUKOVYKH LETATEL'NYKH APPARATOV]

N. N. GLUSHKOV, IU. L. INESHIN, and IU. N. SVIRIDENKO TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 1, 1989, p. 23-28. In Russian. refs

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A panel method is presented for calculating flow past aircraft in the context of the potential theory of an incompressible fluid. The method makes it possible to calculate the complete aircraft configuration, including engine nacelles, suspended loads, and pylons. A characteristic feature of the present method is the principle of symmetric distribution of sources (sinks) and vortices on the opposite surfaces of the lifting elements. Comparisons are made with other analytical methods and experimental data. Isobar calculations over the surface of a transport aircraft are conducted as an example. V.L.

A90-28980

NUMERICAL SOLUTION OF THE PROBLEM OF SUPERSONIC FLOW OF AN IDEAL GAS PAST A TRAPEZOIDAL WEDGE [CHISLENNOE RESHENIE ZADACHI OBTEKANIIA TRAPETSIEVIDNOGO KLINA SVERKHZVUKOVYM POTOKOM IDEAL'NOGO GAZA]

S. M. BOSNIAKOV, V. V. KOVALENKO, S. V. MIKHAILOV, and N. KH. REMEEV TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 1, 1989, p. 29-39. In Russian. refs

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The problem of supersonic flow of an ideal gas past a trapezoidal wedge is solved using a first-order finite difference scheme. The results are compared with results obtained by using a second-order scheme and experimental data. It is shown that the first-order scheme makes it possible to calculate the integral flow characteristics to within 1.5-2 percent, which is sufficient for practical applications. V.L.

A90-28981

CALCULATION OF FLOW CHARACTERISTICS IN THE CORE OF A VORTEX SHEET [RASCHET KHARAKTERISTIK TECHENIIA V IADRE VIKHREVOI PELENY]

A. M. GAIFULLIN TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 1, 1989, p. 40-46. In Russian. refs

Copyright

A method for calculating the core structure of a vortex sheet is described. An empirical criterion is proposed which makes it possible to estimate the location of the vortex burst over a wing. Calculations for a wing/fuselage configuration for Re = 2 x 10 to the 6th are presented. V.L.

A90-28985

EFFECT OF STRUCTURAL ANISOTROPY ON THE DYNAMIC CHARACTERISTICS OF THE WING AND CRITICAL FLUTTER SPEED [VLIIANIE KONSTRUKTIVNOI ANIZOTROPII NA DINAMICHESKIE KHARAKTERISTIKI KRYLA I KRITICHESKUIU SKOROST' FLATTERA]

Z. K. DANILOVA TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 1, 1989, p. 72-80. In Russian.

Copyright

The effect of anisotropy on the dynamic characteristics of a wing and critical flutter speed is analyzed using a simple beam model of an anisotropic straight wing as an example. It is shown that the dynamic characteristics depend not only on the anisotropy orientation angle but also on mass and reinforcement stiffness changes. A qualitative difference between the positive and negative angles of reinforcement fiber orientation is examined. The simple model proposed here makes it possible to solve the problem with little computational requirements. V.L.

A90-28987
INDUCED DRAG OF A WING OF LOW ASPECT RATIO [INDUKTIVNOE SOPROTIVLENIE KRYLA MALOGO UDLINENIIA]
NGUEN DYK KYONG and M. I. NISHT TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 1, 1989, p. 88-92. In Russian.
Copyright
Results of a study of the induced drag of wings of various planforms are presented. The problem is solved by the discrete vortex method in the context of the nonlinear theory of stationary nonseparated flow of an ideal incompressible gas past a thin lifting surface. It is shown that the induced drag of plane wings of low aspect ratio with a suction force is substantially less than that following from the linear theory for the same lift coefficient. It is also shown that sweptforward wings are superior to swept wings even for moderate lift force coefficients. V.L.

A90-28988
COMPARISON OF CALCULATED AND EXPERIMENTAL NONSTATIONARY AERODYNAMIC CHARACTERISTICS OF A DELTA WING PITCHING AT LARGE ANGLES OF ATTACK [SOPOSTAVLENIE RASCHETNYKH I EKSPERIMENTAL'NYKH NESTATSIONARNYKH AERODINAMICHESKIKH KHARAKTERISTIK TREUGOL'NOGO KRYLA, KOLEBLIUSHCHEGOSIA PO TANGAZHU, NA BOL'SHIKH UGLAKH ATAKI]
IU. A. PRUDNIKOV, E. A. CHASOVNIKOV, and G. M. SHUMSKII TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 1, 1989, p. 93-96. In Russian. refs
Copyright
The aerodynamic characteristics of a delta wing of aspect ratio 1 pitching at large angles of attack are calculated by the discrete vortex method, and the results are compared against experimental data. The results confirm the validity of the method for calculating the nonstationary aerodynamic characteristics over the range of angles of attack before the breakup of vortex filaments. V.L.

A90-28989
SOME CHARACTERISTICS OF CHANGES IN THE NONSTATIONARY AERODYNAMIC CHARACTERISTICS OF A WING PROFILE WITH AN AILERON IN TRANSONIC FLOW [NEKOTORYE ZAKONOMERNOSTI IZMENENIIA NESTATSIONARNYKH AERODINAMICHESKIKH KHARAKTERISTIK PROFILIA KRYLA S ELERONOM V TRANSZVUKOVOM POTOKE]
IU. P. NUSHTAEV TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 1, 1989, p. 97-102. In Russian.
Copyright
Changes in the nonstationary aerodynamic characteristics of a wing profile with an aileron in flow of an ideal gas are investigated numerically under conditions of harmonic oscillations in relation to the relative profile thickness, oscillation frequency, and rotation axis position. Vortex-free isentropic flow of an ideal gas is analyzed assuming that perturbations introduced by an oscillating airfoil and the frequencies of the oscillatory motions are small. The problem is reduced to that of solving the well-known Lin-Reissner-Jsien equation for the small perturbation potential. V.L.

A90-28990
CALCULATION OF THE EFFECT OF THE ENGINE NACELLE ON TRANSONIC FLOW PAST A WING [RASCHET VLIIANIIA MOTOGONDOLY NA OBTEKANIE KRYLA TRANSZVUKOVYM POTOKOM]
A. E. OSOVSKII and IU. N. SVIRIDENKO TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 1, 1989, p. 103-107. In Russian. refs
Copyright
An approximate method is presented for determining the effect of the engine nacelle on transonic flow of a gas past a swept wing. The calculation involves the combined use of the panel method and a method for determining transonic flow past an individual wing. Calculations are made for wings of different configurations, and the results are compared with experimental data. V.L.

A90-28991
AERODYNAMIC QUALITY OF A PLANE DELTA WING WITH BLUNTED EDGES AT LARGE SUPERSONIC FLOW VELOCITIES [AERODINAMICHESKOE KACHESTVO PLOSKOGO TREUGOL'NOGO KRYLA S ZATUPLENNYMI KROMKAMI PRI BOL'SHIKH SVERKHZVUKOVYKH SKOROSTIAKH OBTEKANIIA]
P. I. GORENBUKH TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 1, 1989, p. 108-112. In Russian.
Copyright
Experimental data on the aerodynamic quality of plane delta wings with blunted edges are reported for free-stream Mach 9 and Reynolds numbers of 1.2 x 10 to the 6th - 4 x 10 to the 5th. The data are compared with results calculated by the method proposed by Nikolaev (1987). A unified analytical-experimental dependence is obtained for the relative aerodynamic quality near the maximum-aerodynamic-quality regime. V.L.

A90-28992
LAMINAR SEPARATED FLOW ON A BICONICAL BODY AT HIGH SUPERSONIC VELOCITIES [LAMINARNOE OTRYVNOE TECHENIE NA BIKONICHESKOM TELE PRI BOL'SHOI SVERKHZVUKOVOI SKOROSTI]
A. P. KOSYKH, S. K. MARINICHENKO, G. G. NERSESOV, and A. Š. SKURATOV TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 1, 1989, p. 113-119. In Russian. refs
Copyright
Experimental results are presented on gas flow and pressure distribution on the surface of a biconical body with half-angles of taper of 10 and 25 deg for Mach 6, angles of attack 0-9 deg, and Reynolds numbers of (0.36-4.24) x 10 to the 6th. The dependences of the length of the separation zone formed ahead of the rear zone and characteristic pressure in this zone on the Reynolds number and angle of attack are determined. Nonviscous flow past the biconical body is calculated for different angles of attack. A comparison of the analytical and experimental data demonstrates that the separation zone has a substantial effect on surface pressure distribution. V.L.

A90-29003
AUXILIARY HYPOTHESES OF THE WAVE DRAG THEORY [O VSPOMOGATEL'NYKH GIPOTEZAKH TEORII VOLNOVOGO SOPROTIVLENIIA]
A. S. PETROV TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 2, 1989, p. 61-65. In Russian. refs
Copyright
Expressions for the wave drag of a plane body at transonic velocities are examined which follow from three different hypotheses concerning the behavior of hydrodynamic quantities in the vortex wake of a body at infinity. It is found that all the hypotheses investigated lead to the same result, which reflects an increase in entropy in the wake of the body and the irreversibility of the conversion to heat of part of the flow kinetic energy. V.L.

A90-29004
USING THE LIFTING LINE THEORY FOR CALCULATING STRAIGHT WINGS OF ARBITRARY PROFILE [PRIMENENIE TEORII NESUSHCHEI LINII DLIA RASCHETA PRIAMYKH KRYL'EV S PROIZVOL'NYMI PROFILIAMI]
N. A. CHICHEROV TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 2, 1989, p. 66-71. In Russian. refs
Copyright

A wing of large aspect ratio is examined in the context of the lifting line theory, and a lifting line equation is written in a form different from the Prandtl equation. Based on this equation, a modified version of the discrete vortex method is proposed for calculating the aerodynamic characteristics of straight wings with allowance for the real profile characteristics. The results obtained using the approach proposed here are in good agreement with experimental results from different wind tunnels. V.L.

A90-29005
EFFECT OF THE LEADING EDGE BLUNTNESS OF A MODERATELY SWEPT WING ON THE AERODYNAMIC CHARACTERISTICS OF AN AIRCRAFT MODEL AT SUBSONIC AND TRANSONIC VELOCITIES [VLIIANIE ZATUPLENIIA NOSOVOI CHASTI KRYLA UMERENNOI STRELOVIDNOSTI NA AERODINAMICHESKIE KHARAKTERISTIKI MODELI SAMOLETA PRI DOZVUKOVYKH I OKOLOZVUKOVYKH SKOROSTIAKH]
A. E. GONCHAR, V. A. ZHURAVLEV, V. P. KAZNEVSKII, and D. P. KROTKOV TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 2, 1989, p. 72-75. In Russian.
Copyright
Aerodynamic characteristics of an aircraft model with a moderately swept (40 deg) wing are presented for various degrees of leading edge bluntness. Experimental studies were conducted on the model at subsonic and transonic velocities (M 0.6-0.9) over the angle of attack range -2 to -28 deg. It is shown that the bluntness of the wing leading edge makes it possible to increase the maximum aerodynamic quality of the model at subsonic velocities (M 0.6, 0.7) and the aerodynamic quality at large angles of attack at subsonic and transonic velocities (M 0.6-0.9). V.L.

A90-29006
WAVE RIDER VOLUME DISTRIBUTION [O RASPREDELENII OB'EMA VOLNOLETA]
G. I. MAIKAPAR TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 2, 1989, p. 76-80. In Russian.
Copyright
Aerodynamic quality calculations are presented for a wave rider with a trapezoidal base cross section. It is shown that, for given length, width, and lifting force, maximum aerodynamic quality is achieved with a certain wave rider shape. The use of the same shape over the entire volume and lifting force ranges may lead to significant aerodynamic quality losses. V.L.

A90-29012
DIVERGENCE OF THIN-WALLED COMPOSITE RODS OF CLOSED PROFILE IN GAS FLOW [DIVERGENTSIIA KOMPOZITNYKH TONKOSTENNYKH STERZHNEI ZAMKNUTOGO PROFILIA V POTOKE GAZA]
V. V. KOBELEV and A. D. LARICHEV TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 2, 1989, p. 109-113. In Russian. refs
Copyright
The divergence of a composite wing of large aspect ratio in gas flow is analyzed using a model of anisotropic thin-walled rods of closed profile. A solution is obtained in closed form which indicates the effect of anisotropy and cross sectional shape on the critical divergence rate. The applicability limits of the model are defined. V.L.

A90-29181
EFFECT OF A JET ON TRANSONIC FLOW PAST AN AIRFOIL [VLIIANIE STRUI NA OKOLOZVUKOVOE OBTEKANIE PROFILIA]
N. B. VORONTSOVA and S. V. LIAPUNOV TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 3, 1989, p. 1-9. In Russian. refs
Copyright
A method is proposed for calculating transonic flow of a jet past an airfoil. The method involves using the relaxation method to calculate the jet and external flows, which are characterized by different Mach numbers, and then splicing the solutions by means of successive approximations. Difference grids in these regions are constructed using the conformal mapping method. Examples of calculations are presented. V.L.

A90-29182
CALCULATION OF THE DRAG OF FUSELAGE TAIL SECTIONS OF DIFFERENT SHAPES IN SUPERSONIC FLOW OF A NONVISCOUS GAS [RASCHET SOPROTIVLENIIA KHVOSTOVYKH CHASTEI FIUZELIAZHEI RAZLICHNYKH FORM PRI OBTEKANII SVERKHZVUKOVYM POTOKOM NEVIAZKOGO GAZA]
S. A. SHCHENNIKOV and S. V. IAGUDIN TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 3, 1989, p. 10-19. In Russian. refs
Copyright
Calculation of supersonic flow past fuselage tail sections and engine nacelles of different shapes are presented. The three-dimensional flow of a nonviscous gas was calculated using McCormack's scheme; axisymmetric flow was calculated by the characteristic method. The drag coefficients of axisymmetric and plane tail sections of different cross-sectional width/height ratios are compared assuming equal cross-sectional areas. V.L.

A90-29183
CALCULATION OF THE INDUCED DRAG OF A WING WITH ARBITRARY DEFORMATION [RASCHET INDUKTIVNOGO SOPROTIVLENIIA KRYLA S PROIZVOL'NOI DEFORMATSIEI]
F. I. GANIEV and NGUEN DYK KYONG TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 3, 1989, p. 21-29. In Russian. refs
Copyright
A method is proposed for calculating the induced drag of a wing, with or without suction, moving in an ideal incompressible fluid. The approach employs the discrete vortex method in a nonlinear formulation, with the Chaplygin-Zhukovskii condition satisfied at the trailing and side edges. The vortex sheet and vortex section circulation are determined by using successive approximations; the suction force is calculated from the first vortex segments. The possibility of obtaining an aerodynamic efficiency higher than the maximum value determined by the linear theory is demonstrated. V.L.

A90-29184
COMBINED EFFECT OF VISCOSITY AND BLUNTNESS ON THE AERODYNAMIC EFFICIENCY OF A DELTA WING IN FLOW WITH A HIGH SUPERSONIC VELOCITY [SOVMESTNOE VLIIANIE VIAZKOSTI I ZATUPLENIIA NA AERODINAMICHESKOE KACHESTVO TREUGOL'NOGO KRYLA V POTOKE S BOL'SHOI SVERKHZVUKOVOI SKOROST'IU]
P. I. GORENBUKH and V. V. NOSOV TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 3, 1989, p. 30-36. In Russian. refs
Copyright
Supersonic flow past plane delta wings was investigated experimentally in the Reynolds number range 120,000-3,000. In the case of nonviscous flow, the maximum aerodynamic efficiency is shown to correlate with the sigma parameter. For sigma greater than 1/3, the effect of the bluntness of the leading edges of a highly swept wing is negligible, and its aerodynamic characteristics in the region of maximum aerodynamic efficiency are close to those of a wing with a sharp leading edge. V.L.

A90-29194
WALL PRESSURE FLUCTUATION SPECTRA IN SUPERSONIC FLOW PAST A FORWARD FACING STEP [SPEKTRY PRISTENOCHNYKH PUL'SATSII DAVLENIIA PRI SVERKHZVUKOVOM OBTEKANII PEREDNEGO USTUPA]
B. M. EFIMTSOV and V. B. KUZNETSOV TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 3, 1989, p. 111-118. In Russian. refs
Copyright
The structure of pressure fluctuations in the separation region

of a turbulent boundary layer ahead of a forward facing step is examined with reference to the available experimental data. Expressions are obtained which describe, in quantitative terms, the dependence of pressure fluctuation spectra on supersonic flow parameters. These relations make it possible to estimate pressure fluctuation spectra in front of a step and in the characteristic cross sections of the separation zone. V.L.

A90-29360#
APPLICATIONS OF XTRAN3S AND CAP-TSD TO FIGHTER AIRCRAFT
D. M. PITT, D. F. FUGLSANG, and D. V. DROUIN (McDonnell Aircraft Co., Saint Louis, MO) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1340-1348. refs
(Contract F33615-87-C-3212)
(AIAA PAPER 90-1035) Copyright

Two unsteady transonic small-disturbance (TSD) codes, XTRAN3S and CAP-TSD, were used to perform aeroelastic analyses of four fighter aircraft configurations. The XTRAN3S code was used for a wing alone analysis of the F-15 and F/A-18 aircraft while the CAP-TSD code, with its more flexible geometric modeling capability, was used to analyze a canard, wing, and tail arrangement of the F-15 S/MTD and a wing, launcher, and tip missile arrangement of the F/A-18. Static and dynamic aeroelastic calculations were performed using both the linear and the nonlinear forms of the small-disturbance equation. Comparisons are made between the F-15 and F/A-18 wing alone flutter results and those from a linear flutter analysis computed using Doublet Lattice aerodynamics. These comparisons show good agreement for the linear aerodynamics TSD solutions but significant changes in the flutter speed for the nonlinear aerodynamic TSD solutions. Comparisons were also made for the canard/wing/tail and the wing/launcher/tip missile configurations with the corresponding wing alone configurations to access the effects of multiple lifting surfaces and tip stores upon flutter. Author

A90-29361#
COMPUTATION OF STEADY AND UNSTEADY CONTROL SURFACE LOADS IN TRANSONIC FLOW
BALA K. BHARADVAJ (Douglas Aircraft Co., Long Beach, CA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1349-1360. Research supported by McDonnell Douglas Corp. refs
(AIAA PAPER 90-0935) Copyright

A computational procedure based on the transonic full potential equation for the analysis of loads due to steady and oscillatory control surfaces is presented here. The control surface deflection is modeled using an equivalent body velocity approach without modifying the grid. Viscous effects, including mild separation, are modeled using an interactive inverse boundary layer and the transpiration velocity approach. Results are presented for a fighter wing and a transport aircraft wing configuration, for control surfaces located at the trailing edge and the leading edge, for steady as well as oscillatory deflections. Author

A90-29362*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
IMPLICIT FLUX-SPLIT EULER SCHEMES FOR UNSTEADY AERODYNAMIC ANALYSIS INVOLVING UNSTRUCTURED DYNAMIC MESHES
JOHN T. BATINA (NASA, Langley Research Center, Hampton, VA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1361-1369. refs
(AIAA PAPER 90-0936) Copyright

Improved algorithms for the solution of the time-dependent Euler equations are presented for unsteady aerodynamic analysis involving unstructured dynamic meshes. The improvements have been developed recently to the spatial and temporal discretizations used by unstructured grid flow solvers. The spatial discretization involves a flux-split approach which is naturally dissipative and captures shock waves sharply with at most one grid point within the shock structure. The temporal discretization involves an implicit time-integration shceme using a Gauss-Seidel relaxation procedure which is computationally efficient for either steady or unsteady flow problems. For example, very large time steps may be used for rapid convergence to steady state, and the step size for unsteady cases may be selected for temporal accuracy rather than for numerical stability. Steady and unsteady flow results are presented for the NACA 0012 airfoil to demonstrate applications of the new Euler solvers. The unsteady results were obtained for the airfoil pitching harmonically about the quarter chord. The resulting instantaneous pressure distributions and lift and moment coefficients during a cycle of motion compare well with experimental data. The paper presents a description of the Euler solvers along with results and comparisons which assess the capability. Author

A90-29363*# Old Dominion Univ., Norfolk, VA.
UNSTEADY FLOW COMPUTATION OF OSCILLATING FLEXIBLE WINGS
OSAMA A. KANDIL, H. ANDREW CHUANG (Old Dominion University, Norfolk, VA), and AHMED A. SALMAN IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1370-1381. refs
(Contract NAS1-648)
(AIAA PAPER 90-0937) Copyright

The problem of unsteady flow around flexible wings is solved using the unsteady, compressible, thin-layer Navier-Stokes equations in conjunction with the unsteady, linearized, Navier-displacement equations. Starting with the initial shape of the wing, the Navier-Stokes equations are solved on an initial structured grid to obtain the steady-flow solution which is used for the initial conditions. The forced deformation motion of the wing boundaries is then applied, and the problem is solved accurately in time. During the time-accurate stepping, the Navier-displacement equations are used to solve for the grid deformation and sequently, the Navier-Stokes equations are used to solve for the flowfield. Two applications are presented; the first is for a pulsating oscillation of a bending-mode airfoil in transonic flow, and the second is for a bending-mode oscillation of a sharp-edged delta wing in supersonic flow. Author

A90-29364*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NAVIER-STOKES COMPUTATIONS ON SWEPT-TAPERED WINGS, INCLUDING FLEXIBILITY
GURU P. GURUSWAMY (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1382-1394. refs
(AIAA PAPER 90-1152) Copyright

A procedure to couple the Navier-Stokes solutions with modal structural equations of motion is presented for computing aeroelastic responses of flexible fighter wings. The Navier-Stokes flow equations are solved by a finite-difference scheme with dynamic grids. The coupled aeroelastic equations of motion are solved using the linear-acceleration method. The configuration-adaptive dynamic grids are time-accurately generated using the aeroelastically deformed shape of the wing. The coupled calculations are compared with experiments when available. Effects of flexibility and pitch rate are demonstrated for flows with vortices. Turbulent flow computations are also compared with laminar flow computations. Author

A90-29365#
TIME DOMAIN SIMULATIONS OF A FLEXIBLE WING IN SUBSONIC, COMPRESSIBLE FLOW
M. BLAIR (USAF, Research and Development Center, Wright-Patterson AFB, OH), M. H. WILLIAMS, and T. A. WEISSHAAR (Purdue University, West Lafayette, IN) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1395-1404. refs
(AIAA PAPER 90-1153)

A new unsteady aerodynamic method is used to simulate the aeroelastic response of a flexible wing with an aileron control surface. The unique aspect of this aeroelastic simulation is the unsteady aerodynamic simulation method, the time domain panel (TDP) method (Blair, 1989). This is a time-stepping linear aerodynamic algorithm. In the example given here, the TDP algorithm is incorporated into a time-stepping linear-aeroelastic algorithm. The aeroelastic attributes addressed here include structural dynamics and linear unsteady subsonic compressible aerodynamics. Emphasis is placed on generating minimal-order aeroelastic transfer functions which relate control surface motion to sensor motion. These transfer functions have application to the design of control systems where unsteady aerodynamics is important. Author

A90-29366*# Technion - Israel Inst. of Tech., Haifa.
REDUCED SIZE FIRST-ORDER SUBSONIC AND SUPERSONIC AEROELASTIC MODELING
MORDECHAY KARPEL (Technion - Israel Institute of Technology, Haifa) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1405-1417. Research supported by the National Research Council. refs
(Contract NAGW-1708)
(AIAA PAPER 90-1154) Copyright

Various aeroelastic, aeroservoelastic, dynamic-response, and sensitivity analyses are based on a time-domain first-order (state-space) formulation of the equations of motion. The formulation of this paper is based on the minimum-state (MS) aerodynamic approximation method, which yields a low number of aerodynamic augmenting states. Modifications of the MS and the physical weighting procedures make the modeling method even more attractive. The flexibility of constraint selection is increased without increasing the approximation problem size; the accuracy of dynamic residualization of high-frequency modes is improved; and the resulting model is less sensitive to parametric changes in subsequent analyses. Applications to subsonic and supersonic cases demonstrate the generality, flexibility, accuracy, and efficiency of the method. Author

A90-29367#
A REDUCED COST RATIONAL-FUNCTION APPROXIMATION FOR UNSTEADY AERODYNAMICS
W. EVERSMAN (Missouri-Rolla, University, Rolla) and A. TEWARI IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1418-1427. Research supported by McDonnell Aircraft Co. refs
(AIAA PAPER 90-1155) Copyright

An improved method is developed for the approximation of generalized, unsteady aerodynamic forces by a rational transfer function in the Laplace domain. The new method results in a large reduction in the computational cost of an optimized aeroelastic stability analysis when compared with the previous procedures for a given accuracy. Also, while the previous methods produce an ill-conditioned eigenvalue problem when the optimized values of two or more poles of the transfer function are close to one another, the present scheme accounts for such frequent cases consistently. These improvements are due to the use of higher-order poles (as against the simple poles of the conventional methods), without increasing the total number of aerodynamic states of the system, and they make the method applicable to routine transient response calculations. The method employs a nongradient optimizing process for the selection of the nonlinear parameters of the transfer function. Approximations are presented for the three dimensional, subsonic aerodynamics of a high-aspect-ratio wing, and flutter analysis is carried out to demonstrate the advantages of the present method. Author

A90-29368#
FAST CALCULATION OF ROOT LOCI FOR AEROELASTIC SYSTEMS AND OF RESPONSE IN TIME DOMAIN
J. BRINK-SPALINK (Deutsche Airbus GmbH, Hamburg, Federal Republic of Germany) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1428-1431. refs
(AIAA PAPER 90-1156) Copyright

Fast methods for analysis of aeroelastic systems are examined. The determinant interpolation method for calculating the root loci of aeroelastic systems is presented. This method is based on linear eigenvalue computations and complex analytic interpolation of determinants. The finite state modeling and z-transform approach, developed for calculations of unsteady aerodynamic matrices, are described. I.F.

A90-29369*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EXPERIMENTAL TRANSONIC FLUTTER CHARACTERISTICS OF SUPERSONIC CRUISE CONFIGURATIONS
MICHAEL H. DURHAM, STANLEY R. COLE, F. W. CAZIER, JR., DONALD F. KELLER (NASA, Langley Research Center, Hampton, VA), ELLEN C. PARKER (Lockheed Engineering and Sciences Co., Hampton, VA), and W. KEATS WILKIE (NASA, Langley Research Center; U.S. Army, Army Aviation Systems Command, Hampton, VA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1432-1441. refs
(AIAA PAPER 90-0979) Copyright

The flutter characteristics of a generic arrow-wing supersonic transport configuration are studied. The wing configuration has a 3 percent biconvex airfoil and a leading-edge sweep of 73 deg out to a cranked tip with a 60 deg leading-edge sweep. The ground vibration tests and flutter test procedure are described. The effects of flutter on engine nacelles, fuel loading, wing-mounted vertical fin, wing angle-of-attack, and wing tip mass and stiffness distributions are analyzed. The data reveal that engine nacelles reduce the transonic flutter dynamic pressure by 25-30 percent; fuel loadings decrease dynamic pressures by 25 percent; 4-6 deg wing angles-of-attack cause steep transonic boundaries; and 5-10 percent changes in flutter dynamic pressures are the result of the wing-mounted vertical fin and wing-tip mass and stiffness distributions. I.F.

A90-29370#
INFLUENCE OF JOINT FIXITY ON THE AEROELASTIC CHARACTERISTICS OF A JOINED WING STRUCTURE
RONALD STEARMAN (Texas, University, Austin), HUNG-HSI LIN, and JITAI JHOU IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1442-1454. refs
(AIAA PAPER 90-0980) Copyright

A preliminary study was made on how the aeroelastic and strength characteristics of a proposed joined-wing aircraft are influenced by the type of joint employed to attach the wings together. Both experimental and analytical modeling were utilized in the study on a configuration that was geometrically similar to the proposed JW-1 joined-wing flight demonstrator aircraft. The joint structural characteristics were classified according to the number of reaction loads that they transmit between the wings. A total of eight joint configurations were studied and evaluated for the JW-1 cruise-flight loading condition. The optimal joint configuration was found to differ for strength as compared to that needed for stiffness requirements. Furthermore, when considering strength requirements only, an optimal joint tradeoff occurs as a function of the distribution of total lift between the front and rear wings. Finally, when considering the best tradeoff between strength and stiffness requirements, a joint that transmits the largest number of reaction loads was found to be the overall optimal configuration. Author

A90-29371*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

EFFECTS OF SPOILER SURFACES ON THE AEROELASTIC BEHAVIOR OF A LOW-ASPECT-RATIO RECTANGULAR WING

STANLEY R. COLE (NASA, Langley Research Center, Hampton, VA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1455-1463. refs

(AIAA PAPER 90-0981) Copyright

The relationship between spoiler surfaces and flutter for a low-aspect ratio, rectangular wing is examined. The model design is a rigid wing mounted to the wing tunnel wall using a flexible, rectangular beam. The spoiler surface is composed of thin, rectangular aluminum plates that are vertically mounted to the wing surface. The effects of changes in spoiler geometry and location on wing flutter are studied using wind tunnel testing. It is determined that increases in spoiler height and weight cause an increase in the flutter dynamic pressure; however, variations in the location of the spoiler surfaces have little effect on flutter. Diagrams of the wing model are provided. I.F.

A90-29374*# Toledo Univ., OH.

TIME DOMAIN FLUTTER ANALYSIS OF CASCADES USING A FULL-POTENTIAL SOLVER

MILIND A. BAKHLE, T. S. R. REDDY, and THEO G. KEITH, JR. (Toledo, University, OH) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1489-1496. refs

(Contract NSG-3139)

(AIAA PAPER 90-0984) Copyright

A time domain approach is used to determine the dynamic aeroelastic stability of a cascade of blades. The structural model for each blade is a typical section with two degrees of freedom. The aerodynamic model is the unsteady, two-dimensional, full-potential flow through the cascade of airfoils. The unsteady equations of motion for the structure and the fluid are integrated simultaneously in time starting with the steady flowfield and a small initial disturbance applied to the airfoils. The motion of each blade is analyzed to determine the aeroelastic stability of the cascade. The effect of interblade phase angle is included in the analysis by allowing each blade to have an independent motion and considering a number of blade passages. Calculations are made using an airfoil section and structural parameters that are representative of a propfan. The results are compared with those from a separate frequency domain analysis. Good agreement between the results is observed. With the time domain approach, it is possible to consider nonlinear structural models and nonlinear force-displacement relations. The method allows a realistic simulation of the motion of the fluid and the cascade blades for a better physical understanding and it also has the potential for saving computational time when compared to the frequency domain approach for the flutter analysis of cascades. Author

A90-29375#

NONLINEAR AEROELASTICITY

EARL H. DOWELL (Duke University, Durham, NC) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1497-1509. refs

(AIAA PAPER 90-1031) Copyright

The physical domain of nonlinear aeroelasticity and the effects of nonlinearity on the development of mathematical models are discussed. Attention is given to the flutter of plates, shells, and airfoils; bluff body oscillations in a flowing fluid; and the aerodynamic behavior of hingeless helicopter rotor blades. Linear and nonlinear models and degrees of freedom are examined. The use of linear, dynamic models for transonic flutter analysis is illustrated with various examples. I.F.

A90-29376*# McDonnell Aircraft Co., Saint Louis, MO.

AEROELASTIC ANALYSIS OF WINGS USING THE EULER EQUATIONS WITH A DEFORMING MESH

BRIAN A. ROBINSON (McDonnell Aircraft Co., Saint Louis, MO), JOHN T. BATINA (NASA, Langley Research Center, Hampton, VA), and HENRY T. Y. YANG (Purdue University, West Lafayette, IN) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1510-1518. refs

(Contract NAG1-372)

(AIAA PAPER 90-1032) Copyright

Modifications to the CFL3D three-dimensional unsteady Euler/Navier-Stokes code for the aeroelastic analysis of wings are described. The modifications involve including a deforming mesh capability which can move the mesh to continuously conform to the instantaneous shape of the aeroelastically deforming wing, and including the structural equations of motion for their simultaneous time-integration with the governing flow equations. Calculations were performed using the Euler equations to verify the modifications to the code and as a first-step toward aeroelastic analysis using the Navier-Stokes equations. Results are presented for the NACA 0012 airfoil and a 45 deg sweptback wing to demonstrate applications of CFL3D for generalized force computations and aeroelastic analysis. Comparisons are made with published Euler results for the NACA 0012 airfoil and with experimental flutter data for the 45 deg sweptback wing to assess the accuracy of the present capability. These comparisons show good agreement and, thus, the CFL3D code may be used with confidence for aeroelastic analysis of wings. The paper describes the modifications that were made to the code and presents results and comparisons which assess the capability. Author

A90-29377*# Lockheed Engineering and Sciences Co., Hampton, VA.

USING TRANSONIC SMALL DISTURBANCE THEORY FOR PREDICTING THE AEROELASTIC STABILITY OF A FLEXIBLE WIND-TUNNEL MODEL

WALTER A. SILVA (Lockheed Engineering and Sciences Co., Hampton, VA) and ROBERT M. BENNETT (NASA, Langley Research Center, Hampton, VA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers, Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1519-1529. refs

(AIAA PAPER 90-1033)

The CAP-TSD (Computational Aeroelasticity Program-Transonic Small Disturbance) code, developed at the NASA-Langley Research Center, is applied to the Active Flexible Wing (AFW) wind-tunnel model for prediction of the model's transonic aeroelastic behavior. Static aeroelastic solutions using CAP-TSD are computed. Dynamic (flutter) analyses are then performed as perturbations about the static aeroelastic deformations of the AFW. The accuracy of the static aeroelastic procedure is investigated by comparing analytical results to those from previous AFW wind-tunnel experiments. Dynamic results are presented in the form of root loci at different Mach numbers for a heavy gas and air. The resultant flutter boundaries for both gases are also presented. The effects of viscous damping and angle-of-attack, on the flutter boundary in air, are presented as well. Author

A90-29378#
CHAOTIC RESPONSE OF AEROSURFACES WITH STRUCTURAL NONLINEARITIES (STATUS REPORT)
ANTHONY J. HAUENSTEIN, ROBERT M. LAURENSON (McDonnell Douglas Missile Systems Co., Saint Louis, MO), WALTER EVERMAN, GREZEGORZ GALECKI (Missouri-Rolla, University, Rolla), ANTHONY K. AMOS (Pennsylvania State University, University Park) et al. IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers, Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1530-1539. refs
(Contract F49620-88-C-0047)
(AIAA PAPER 90-1034) Copyright

An analytical and experimental aeroelastic investigation of aerodynamic surfaces with discrete structural nonlinearities is being conducted. This paper presents results for a two degree of freedom, rigid aerosurface. Four types of oscillatory response; damped decay, limit cycle, chaotic, and flutter; were observed in both the analytical and experimental results. The analysis technique used was an unsteady aerodynamic transient response simulation program. This technique proved useful and accurate in predicting the critical airspeeds at which the system response transitioned from damped decay to sustained oscillation and from sustained oscillation to divergent oscillation, i.e. flutter. Difficulty exists when attempting to analytically predict the type of sustained oscillation, either limit cycle or chaotic, that the experimental system experiences. Possible solutions to this problem are discussed. Author

A90-29383#
SIMULATION OF STATIC AND DYNAMIC AEROELASTIC BEHAVIOR OF A FLEXIBLE WING WITH MULTIPLE CONTROL SURFACES
H. IDE and D. OMINSKY (Rockwell International Corp., Los Angeles, CA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1582-1588. Research supported by the Rockwell International Independent Research and Development Program. refs
(AIAA PAPER 90-1075) Copyright

A recent CFD/Control analysis of a single surface control scenario showed it to be promising for suppressing flutter and perhaps controlling undesired nonlinear phenomena which may be the direct or indirect cause of transonic dynamic problems. This analysis has been possible because the coupling phenomena between aerodynamics, structural deformation and controls can be analyzed without great difficulty in the framework of CFD and a time-dependent potential formulation. The accuracy of the CFD codes in the transonic region have been verified by comparing them with experimental data, giving great confidence to this type of analysis. The previous study demonstrated how a control law can be analyzed for its effectiveness on wing oscillation using Rockwell's three-dimensional full potential code. In this study, the concept is expanded to analyze multiple surface control laws (single-input-multi-output) for their effectiveness. Author

A90-29387*# California Univ., Los Angeles.
ROTARY-WING AEROELASTICITY WITH APPLICATION TO VTOL VEHICLES
PERETZ P. FRIEDMANN (California, University, Los Angeles) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1624-1670. refs
(Contract NAG2-477; NAG1-833)
(AIAA PAPER 90-1115) Copyright

This survey presents an assessment of the state of the art in rotary-wing aeroelasticity as applied to conventional helicopters as well as other VTOL vehicles such as tilting prop-rotors, the X-wing and a hybrid heavy lift vehicle. The objective is to enable the reader to develop an awareness of what has been accomplished, what remains to be done, and where to find more comprehensive treatments of the various topics discussed. The main topics discussed are: (1) structural modeling; (2) unsteady aerodynamic modeling; (3) formulation of the equations of motion and their solutions; (4) illustrative results for isolated blades in hover and forward flight; (5) illustrative results for coupled rotor/fuselage problems; (6) active control of aeromechanical and aeroelastic problems; (7) active controls for vibration reduction; (8) structural optimization with aeroelastic constraints; (9) gust response analysis of rotors; and (10) aeroelastic problems in special VTOL vehicles. These topics are reviewed with different levels of detail and some useful observation on potentially rewarding areas of future research are made. Author

A90-29388#
COMPUTATIONAL PREDICTION OF STALL FLUTTER IN CASCADED AIRFOILS
F. SISTO, S. THANGAM, and A. ABDEL-RAHIM (Stevens Institute of Technology, Hoboken, NJ) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1671-1678. refs
(AIAA PAPER 90-1116) Copyright

A computational scheme based on a modified form of the vortex methods is described. The scheme is used to simulate the flow over an infinite linear cascade of airfoils. The model is based on a two-dimensional characteristic section with one-degree of freedom in either torsion or bending. A time-marching technique is employed to solve aerodynamic loading and the structural displacements. It is observed that over a measured finite interval of blade frequency the stall frequency becomes entrained and synchronization of the two frequencies occurs. Proposals for improving computational studies are presented and their impacts on designs are discussed. I.F.

A90-29390#
AEROELASTIC ANALYSIS OF HELICOPTER ROTOR BLADES WITH ADVANCED TIP SHAPES
KI-CHUNG KIM and INDERJIT CHOPRA (Maryland, University, College Park) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1690-1713. refs
(Contract DAAL03-88-C-002)
(AIAA PAPER 90-1118) Copyright

A systematic investigation of the effects of tip sweep, anhedral and planform taper on helicopter rotor blade response and loads is conducted using comprehensive structural and aerodynamic models. A finite element method is used for the structural analysis, and a three-dimensional (3D) finite difference aerodynamic analysis based on unsteady transonic small disturbance theory is used to calculate the aerodynamic forces. The blade and its tip are treated as elastic beams undergoing flap bending, lag bending, elastic twist and axial deflections. Nonlinear transformation relations based on moderate rotations are used to assemble the blade and tip elements. The blade response is calculated from nonlinear periodic normal mode equations using a finite element in time scheme. Vehicle trim and rotor elastic response are calculated as one coupled solution using the Newton method. Tip sweep introduces a kinematic axial-lag coupling and a straightening effect of the centrifugal forces, which significantly influence the lag dynamics. Three-dimensional aerodynamic effects on torsional response are quite considerable for swept-tip and anhedral-tip blades. Author

A90-29391#
ROTOR/AIRFRAME AEROELASTIC ANALYSES USING THE TRANSFER MATRIX APPROACH

K. B. SANGHA, R. K. WEISENBURGER, and F. K. STRAUB (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1714-1726. refs
(AIAA PAPER 90-1119) Copyright

The transfer matrix approach has been employed in a number of analyses in the rotorcraft industry. The method has distinct advantages in response and load calculations. McDonnell Douglas Helicopter Company (MDHC) has employed the transfer matrix approach in a unique manner to solve the highly coupled, nonlinear problem of combined rotor-fuselage aeroelasticity. The software developed toward this purpose is the Rotor/Airframe Comprehensive Aeroelastic Program (RACAP). This paper describes in detail the formulation of the problem, the validation of the software through the solution of a beam nonlinear response and eigenvalue problem, and the correlation obtained on the AH-64 helicopter. The influence of a variety of aerodynamic models on the loads is described, and finally, conclusions are presented outlining the advantages and limitations of the approach. Author

A90-29392*# Purdue Univ., West Lafayette, IN.
THREE DIMENSIONAL FULL POTENTIAL METHOD FOR THE AEROELASTIC MODELING OF PROPFANS
MARC H. WILLIAMS (Purdue University, West Lafayette, IN) and CHIEH C. KU IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1727-1735. refs
(Contract NAG3-499)
(AIAA PAPER 90-1120) Copyright

A three-dimensional time dependent full potential aerodynamic analysis of single rotation propellers has been developed. The primary purpose of the code is to provide a capability of doing propfan aeroelastic analysis in the nonlinear transonic regime. A secondary purpose is to provide a validation of the unsteady lifting surface panel method that has been have developed. Results will be shown for steady state aerodynamic loading, unsteady aerodynamic response to forced aeroelastic deformations, and free aeroelastic response. Comparisons are made to experimental data and corresponding panel code results. Author

A90-29393*# California Univ., Los Angeles.
AEROELASTIC PROBLEMS IN TURBOMACHINES
ODDVAR O. BENDIKSEN (California, University, Los Angeles) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1736-1761. Research supported by NSF. refs
(Contract NAG3-308; NAS3-25574)
(AIAA PAPER 90-1157) Copyright

A review of the field of turbomachinery aeroelasticity is presented. Developments over the past decade are emphasized, and an assessment of possible future directions of research is offered. The paper reviews the areas of unsteady cascade flows, structural modeling, and flutter prediction methods. Representative results for unsteady flow calculations and flutter boundary predictions in subsonic, transonic, and supersonic flows are discussed, including recent calculations based on the methods of computational fluid mechanics. Results from current attempts to correlate experimental data with theoretical predictions are discussed briefly. It is recommended that future research include investigations of novel approaches to flutter calculations that can take full advantage of parallel processing supercomputers. The feasibility of using mistuning and aeroelastic tailoring as passive flutter suppression techniques should also be pursued. Author

A90-29397#
WHIRL FLUTTER STABILITY OF A PUSHER CONFIGURATION SUBJECT TO A NONUNIFORM FLOW
F. NITZSCHE and E. A. RODRIGUES (Empresa Brasileira de Aeronautica, S.A., Sao Jose dos Campos, Brazil) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1805-1812. refs
(AIAA PAPER 90-1162) Copyright

The whirl flutter stability of a pusher propeller configuration immersed in the nonuniform flow field generated by many aerodynamic interference elements positioned upstream the propeller disk is analyzed. A panel method idealization for the complete aircraft, followed by a numerical integration of the propeller aerodynamic coefficients over the propeller disk allows the formulation of the problem in terms of the study of the stability characteristics of a periodic system, for which Floquet's theory can be efficiently applied. Author

A90-29591
THE EFFECT OF WALLS ON A SPATIALLY GROWING SUPERSONIC SHEAR LAYER
PAUL E. DIMOTAKIS, TOSHI KUBOTA (California Institute of Technology, Pasadena), and ZHUANG MEI Physics of Fluids A (ISSN 0899-8213), vol. 2, April 1990, p. 599-604. refs
(Contract AF-AFOSR-88-0155)
Copyright

The inviscid instability, with respect to supersonic disturbances of a spatially growing plane mixing layer inside parallel flow guide walls, is investigated using linear stability analysis. For supersonic convective Mach numbers, it is found that the maximum amplification rates of the shear layer approach an asymptotic value and that this maximum amplification rate increases to its maximum value and decreases again as the distance between the walls decreases continuously. Contour plots of the pressure perturbation fields indicate that there are waves propagating outward from the shear layer along the Mach angle, and that the walls provide a feedback mechanism between the growing shear layer and this compression/expansion wave system. The streak lines of the flow confirm that the spreading rate of the shear layer is unusually small for supersonic disturbances. Author

A90-29687#
ACCURATE NAVIER-STOKES RESULTS FOR THE HYPERSONIC FLOW OVER A SPHERICAL NOSETIP
FREDERICK G. BLOTTNER (Sandia National Laboratories, Albuquerque, NM) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 27, Mar.-Apr. 1990, p. 113-122. Previously cited in issue 18, p. 2761, Accession no. A89-43194. refs
(Contract DE-AC04-76DP-00789)

A90-29695*# Scientific Research and Technology, Inc., Hampton, VA.
HYPERSONIC VISCOUS SHOCK-LAYER SOLUTIONS OVER LONG SLENDER BODIES. II - LOW REYNOLDS NUMBER FLOWS
K. P. LEE, R. N. GUPTA (Scientific Research and Technology, Inc., Hampton, VA), E. V. ZOBY, and J. N. MOSS (NASA, Langley Research Center, Hampton, VA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 27, Mar.-Apr. 1990, p. 185-193. Previously cited in issue 10, p. 1431, Accession no. A89-28251. refs
Copyright

A90-29882
UNSTEADY TRANSONIC AERODYNAMICS
DAVID NIXON, ED. (Nielsen Engineering and Research, Inc., Mountain View, CA) Washington, DC, American Institute of Aeronautics and Astronautics, Inc. (Progress in Astronautics and Aeronautics. Volume 120), 1989, 394 p. For individual items see A90-29883 to A90-29889.
Copyright

Various papers on unsteady transonic aerodynamics are presented. The topics addressed include: physical phenomena associated with unsteady transonic flows, basic equations for unsteady transonic flow, practical problems concerning aircraft, basic numerical methods, computational methods for unsteady transonic flows, application of transonic flow analysis to helicopter rotor problems, unsteady aerodynamics for turbomachinery aeroelastic applications, alternative methods for modeling unsteady transonic flows. C.D.

A90-29883#
PHYSICAL PHENOMENA ASSOCIATED WITH UNSTEADY TRANSONIC FLOWS
D. G. MABEY (Royal Aerospace Establishment, Aeronautics Laboratory, Bedford, England) IN: Unsteady transonic aerodynamics. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1989, p. 1-55. refs
Copyright

The wide range of physical phenomena associated with unsteady transonic flow is reviewed. The development of these flows is described, and inviscid transonic flow in an oscillating airfoil is discussed. Unsteady shock motions are addressed, and the nature and importance of the aerodynamic excitation or buffet at transonic speeds is examined. Transonic flutter problems are considered, and an introduction is given to some of the experimental problems in time-dependent aerodynamics that may be important at transonic speeds. Two examples are used to show how the modification of time-dependent boundary conditions can strongly influence the development of unsteady transonic flows. C.D.

A90-29884#
BASIC EQUATIONS FOR UNSTEADY TRANSONIC FLOW
DAVID NIXON (Nielsen Engineering and Research, Inc., Mountain View, CA) IN: Unsteady transonic aerodynamics. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1989, p. 57-73. refs
Copyright

The most complex flow that is encountered at transonic speeds occurs when an aircraft undergoes an unsteady motion of large amplitude, due either to aeroelastic forces or maneuver. Because the equations describing such flows are very difficult to solve, it is desirable to look for simplifications. Here, the simplest physical problem that must be modeled, that of two-dimensional, attached flow with shock waves, is examined. The basic equations are developed and the resulting systems of equations that may be used for a transonic flow prediction are found. The correct choice of boundary conditions is addressed, and some aspects of transonic potential theory are discussed. C.D.

A90-29885#
PRACTICAL PROBLEMS - AIRPLANES
ATLEE M. CUNNINGHAM, JR. (General Dynamics Corp., Fort Worth, TX) IN: Unsteady transonic aerodynamics. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1989, p. 75-132. refs
Copyright

Unsteady transonic phenomena are addressed insofar as they affect aircraft. Flutter, limit cycle oscillations, maneuver aerodynamics, control reversal, buzz, active control technology needs, gust response and alleviation, and unsteady shock-vortex interaction are discussed. Three-dimensional effects on real aircraft are stressed. C.D.

A90-29886*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
BASIC NUMERICAL METHODS
JOSEPH L. STEGER and WILLIAM R. VAN DALSEM (NASA, Ames Research Center, Moffett Field, CA) IN: Unsteady transonic aerodynamics. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1989, p. 133-209. refs
Copyright

Some of the basic finite-difference schemes that can be used to solve the nonlinear equations that describe unsteady inviscid and viscous transonic flow are reviewed. Numerical schemes for solving the unsteady Euler and Navier-Stokes, boundary-layer, and nonlinear potential equations are described. Emphasis is given to the elementary ideas used in constructing various numerical procedures, not specific details of any one procedure. C.D.

A90-29887*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
APPLICATION OF TRANSONIC FLOW ANALYSIS TO HELICOPTER ROTOR PROBLEMS
F. X. CARADONNA (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: Unsteady transonic aerodynamics. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1989, p. 263-285. refs

The transonic aspect of helicopter flow analysis is addressed. The equations of motion and their implementations are examined, and the computation of real rotor flows is considered. Nonlifting rotor flows, high-speed hover, high advance ratio lifting rotor flows, and strong blade/vortex interaction computations are discussed. C.D.

A90-29888# United Technologies Research Center, East Hartford, CT.
UNSTEADY AERODYNAMICS FOR TURBOMACHINERY AEROELASTIC APPLICATIONS
JOSEPH M. VERDON (United Technologies Research Center, East Hartford, CT) IN: Unsteady transonic aerodynamics. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1989, p. 287-347. Research supported by United Technologies Corp., NASA, and U.S. Navy. refs
Copyright

Vibration problems encountered with axial flow turbomachinery blading are described. The major assumptions invoked in the developments of unsteady aerodynamic analyses intended for turbomachinery aeroelastic design applications are stated. Theoretical models addressing the requirements of unsteady aerodynamic analyses are described, emphasizing two-dimensional, linearized inviscid theories. One theory which accounts for the effects of blade geometry, mean loading, and transonic phenomena on the unsteady aerodynamic response at a blade surface is given special emphasis. The governing equations of this theory which account for the effects of external aerodynamic excitation and of self-excited blade vibrations are given. Examples of response predictions are presented to illustrate features of the unsteady aerodynamic response to blade vibrations and to indicate the status of solution procedures for linearized unsteady flows. C.D.

A90-29889#
ALTERNATIVE METHODS FOR MODELING UNSTEADY TRANSONIC FLOWS
DAVID NIXON (Nielsen Engineering and Research, Inc., Mountain View, CA) IN: Unsteady transonic aerodynamics. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1989, p. 349-376. refs
Copyright

Integral equation methods for predicting unsteady transonic flows are discussed. Local linearization techniques for the transonic small-disturbance (TSD) equation are considered. The use of the transonic 'indicial' method to reduce the amount of computation needed in using the TSD equation is addressed. C.D.

A90-30264*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NUMERICAL SOLUTIONS OF THE LINEARIZED EULER EQUATIONS FOR UNSTEADY VORTICAL FLOWS AROUND LIFTING AIRFOILS
JAMES R. SCOTT (NASA, Lewis Research Center, Cleveland, OH) and HAFIZ M. ATASSI (Notre Dame, University, IN) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 20 p. Previously announced in STAR as N90-17562. refs
(AIAA PAPER 90-0694) Copyright

A linearized unsteady aerodynamic analysis is presented for unsteady, subsonic vortical flows around lifting airfoils. The analysis fully accounts for the distortion effects of the nonuniform mean flow on the imposed vortical disturbances. A frequency domain numerical scheme which implements this linearized approach is described, and numerical results are presented for a large variety of flow configurations. The results demonstrate the effects of airfoil thickness, angle of attack, camber, and Mach number on the unsteady lift and moment of airfoils subjected to periodic vortical gusts. The results show that mean flow distortion can have a very strong effect on the airfoil unsteady response, and that the effect depends strongly upon the reduced frequency, Mach number, and gust wave numbers. Author

A90-30334
SKIN EFFECT IN FLOW OF A DISPERSE FLUID PAST A WING PROFILE [SKIN-EFFEKT PRI OBTEKANII PROFILIA KRYLA DISPERSNOI ZHIDKOST'IU]
S. K. BETIAEV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Jan.-Feb. 1990, p. 49-55. In Russian. refs
Copyright
A mathematical model is proposed which describes the skin effect in a thin film of impurity particles formed on the surface of a wing in the path of flow of a disperse fluid. A classification of possible flow regimes is presented. The influence of the skin effect on the integral aerodynamic characteristics of a wing moving in a heavy rain is discussed. V.L.

A90-30339
DETERMINATION OF THE SPECIFIC THRUST IN OPEN REGIMES AND DESIGN OF A NONSEPARATING CONVERGENT NOZZLE PROFILE [OPREDELENIE UDEL'NOI TIAGI NA NEZAPERTYKH REZHIMAKH I POSTROENIE BEZOTRYVNOGO KONTURA SUZHAIUSHCHEGOSIA SOPLA]
R. K. TAGIROV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Jan.-Feb. 1990, p. 158-164. In Russian. refs
Copyright
Results of specific impulse and flow rate calculations for conical convergent nozzles, changes in specific thrust are analyzed as a function of the wall angle using an ideal gas model. In open regimes, nozzles with different wall angles are shown to have practically the same specific thrusts for both subcritical and supercritical pressure gradients. For pressure gradients characteristic of convergent nozzles (less than 6), conical convergent nozzles with wall angles of 30-90 deg have practically the same values of specific thrust that are maximum in comparison with the specific thrust of nozzles with wall angles less than 30 deg. V.L.

A90-30342
AERODYNAMIC CHARACTERISTICS OF WAVE RIDERS BASED ON FLOWS BEHIND AXISYMMETRIC SHOCK WAVES [AERODINAMICHESKIE KHARAKTERISTIKI VOLNOLETOV, POSTROENNYKH NA TECHENIIAKH ZA OSESIMMETRICHNYMI SKACHKAMI UPLOTNENIIA]
V. I. VORONIN and A. I. SHVETS Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Jan.-Feb. 1990, p. 183-185. In Russian.
Copyright
A method for the numerical calculation of the parameters of flow behind axisymmetric shock waves is briefly described. Aerodynamic characteristics are presented for wave riders whose compression surfaces are based on flows behind axisymmetric power-law shock waves. These characteristics are then compared with the aerodynamic characteristics of wave riders with plane compression surfaces. V.L.

A90-30344
FLOW RATE AND THRUST COEFFICIENTS FOR BIAXIAL FLOWS IN A CONVERGENT NOZZLE [O KOEFFITSIENTAKH RASKHODA I TIAGI DLIA DVUKHSLOINYKH TECHENII V SUZHAIUSHCHEMSIA SOPLE]
N. M. BELIANIN Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Jan.-Feb. 1990, p. 187-189. In Russian.
Copyright
The direct problem of a critical gas flow in a convergent nozzle is analyzed for the case of a two-layer flow with specified flow rate, full pressure, and stagnation temperature ratios. Approximate formulas for the drag and thrust coefficients are obtained, and calculation results are compared with results obtained by using exact relations. V.L.

A90-31119#
AN INTEGRAL METHOD FOR TRANSONIC FLOWS
CHRISTIAN MASSON (McGill University, Montreal, Canada) and ION PARASCHIVOIU (Ecole Polytechnique, Montreal, Canada) (CASI, Symposium on Aerodynamics, 1st, Ottawa, Canada, Dec. 4, 5, 1989) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 36, March 1990, p. 18-23. refs
The present work concerns the application of a numerical method and the development of a computer code for the design and analysis of wing sections in transonic regime. A new approach, the Field Panel Method, is used in order to combine the advantages of panel methods with the solution techniques appropriate to the nonlinear transonic regime. This new approach, with its rectangular grid, is actually the only one to offer the possibility of treating very complex configurations by avoiding all boundary conditions on the grid points. Comparisons with experimental data and with commercial computer code have validated the results. The main advantages of this approach is to supply the Canadian aeronautics manufactures with a design tool adapted to complex configurations. Author

A90-31276#
WIND-TUNNEL INVESTIGATION OF WING-IN-GROUND EFFECTS
M. D. CHAWLA (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH), L. C. EDWARDS (U.S. Army, Safety Center, Fort Rucker, AL), and M. E. FRANKE (USAF, Institute of Technology, Wright-Patterson AFB, OH) Journal of Aircraft (ISSN 0021-8669), vol. 27, April 1990, p. 289-293. Previously cited in issue 16, p. 2593, Accession no. A88-40716.

A90-31278*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMPARISON BETWEEN EXPERIMENTAL AND NUMERICAL RESULTS FOR A RESEARCH HYPERSONIC AIRCRAFT
PAMELA F. RICHARDSON (NASA, Langley Research Center, Hampton, VA), EDWARD B. PARLETTE (Vigyan Research Associates, Inc., Hampton, VA), JOSEPH H. MORRISON, GEORGE F. SWITZER, A. DOUGLAS DILLEY (Analytical Services and Materials, Inc., Hampton, VA) et al. Journal of Aircraft (ISSN 0021-8669), vol. 27, April 1990, p. 300-305. Previously cited in issue 09, p. 1271, Accession no. A89-25025. refs
Copyright

A90-31288#
SIMPLE MARCHING-VORTEX MODEL FOR TWO-DIMENSIONAL UNSTEADY AERODYNAMICS
JAMES DELAURIER and JAMES WINFIELD (Toronto, University, Canada) Journal of Aircraft (ISSN 0021-8669), vol. 27, April 1990, p. 376-378. Research supported by NSERC. refs
Copyright
A single bound-vortex representation has been combined with the marching-vortex wake of Fairgrieve and DeLaurier (1982), to produce a simple analytical model for an unsteady airfoil capable of yielding accurate values of the normal force, moment, and leading-edge suction. The model can be implemented on small computers, using a sequence of repetitive and straightforward calculations. Comparisons with exact solutions for indicial and harmonically oscillating motions indicate excellent model results. O.C.

A90-31479#
CALCULATIONS OF TRANSONIC FLOWS OVER WING-BODY COMBINATIONS

ZUOBIN CHEN, YULUN ZHANG, and FURU YAO (China Aerodynamic Research and Development Center, Mianyang, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 8, March 1990, p. 25-31. In Chinese, with abstract in English. refs

Holst's (1982) AF2 factorization scheme is extended to the solution of transonic potential flows over arbitrary wing-body combinations. The body-fitted computational grid is generated by the solution of an elliptic equation system. Test cases demonstrate that the method is reliable and economic, and can be applied for engineering purposes. Author

A90-31485#

THE NUMERICAL SIMULATION OF THE LOW SPEED AERODYNAMIC CHARACTERISTICS OF A SET OF CLOSE-COUPLED CANARD CONFIGURATIONS

YANSUN XIANG (China Aerodynamic Research and Development Center, Mianyang, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 8, March 1990, p. 71-75. In Chinese, with abstract in English. refs

By the use of the leading-edge vortex flow simulation method in potential flow, the aerodynamic numerical calculation of a set of close-coupled canard configurations has been conducted. Under certain main wing and canard positions and geometric parameter selection, the leading-edge vortex breakdown on the main wing is delayed so that the normal force of the main wing is increased, compared with the canard off case. The suction force on the upper surface of the main wing caused by the canard vortex and the circuit variation of the main wing also contributes to the normal force on the main wing. Author

A90-31486#

GALERKIN FINITE ELEMENT METHOD FOR TRANSONIC FLOW ABOUT AIRFOILS AND WINGS

YIZHAO WU and ZUOSHENG YANG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 8, March 1990, p. 76-83. In Chinese, with abstract in English. refs

The Galerkin finite element method for transonic flow about airfoils and wings is given. The computational domain is discretized by a series of elements with adaptable shapes. The linear interpolation function is used in each element. For supersonic flow, SLOR and an upwind technique suitable to FEM are employed. The method is successful in the computation of transonic flow about airfoils and wings with blunt noses. Author

A90-31489#

VORTEX METHOD MODELLING THE UNSTEADY MOTION OF A THICK AIRFOIL

MENGPING ZHANG and HUIYANG MA (University of Science and Technology of China, Hefei, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 8, March 1990, p. 94-97. In Chinese, with abstract in English.

The unsteady motion of a two-dimensional thick airfoil at high angles of attack is considered. The source and vorticity distributed on the airfoil surface are used to model the thick and lift effects. The discrete vortex method is used to model the wake sheet and the leading-edge separated vortex sheet. The pitching oscillation motion of the airfoil at a high angle of attack is computed. Author

A90-31493

THE BOUNDARY-LAYER FENCE - BARRIER AGAINST THE SEPARATION PROCESS [GRENZSCHICHTZAUN - BARRIERE GEGEN DEN ABREISSVORGANG]

WOLFGANG LIEBE Luft- und Raumfahrt (ISSN 0173-6264), vol. 11, 1st Quarter, 1990, p. 30-34. In German.

Copyright

The history of using aircraft boundary-layer fences to prevent the laminar-to-turbulent transition process is reviewed. The effectiveness of different aircraft and wing types in achieving this goal is described. The physics involved is explained. C.D.

N90-18364* McDonnell Aircraft Co., Houston, TX. Engineering Technology Div.

RESEARCH ON A TWO-DIMENSIONAL INLET FOR A SUPERSONIC V/STOL PROPULSION SYSTEM. APPENDIX A Final Report, Sep. 1979 - Jun. 1984

J. L. MARK, M. A. MCGARRY, and P. V. REAGAN Jun. 1984 880 p

(Contract NAS3-22158)

(NASA-CR-174945; NAS 1.26:174945) Avail: NTIS HC A99/MF E06 CSCL 01A

The inlet system performance requirements associated with supersonic V/STOL aircraft place extreme demands on the inlet designer. The present effort makes maximum use of flow improvement techniques, proven for high subsonic maneuvering flight and adapts them to the critical static and low speed/high angle-of-attack flight regime of the supersonic V/STOL aircraft. A description of the aerodynamic design, model characteristics, data analysis, discussion, and conclusions concerning the most promising inlet design approaches are contained. The appendix contains the reduced wind tunnel data plots and pressure distribution. Author

N90-18365# Institut Franco-Allemand de Recherches, Saint-Louis (France).

PREDICTION OF ROTOR BLADE-VORTEX INTERACTION NOISE FROM 2-D AERODYNAMIC CALCULATIONS AND MEASUREMENTS

J. HAERTIG and M. CAPLOT (Office National d'Etudes et de Recherches Aerospatiales, Paris, France) 3 Nov. 1988 23 p Presented at 14th European Rotorcraft Forum, Milan, Italy, 20-23 Sep. 1988 Previously announced in IAA as A89-29280 Sponsored by Direction des Recherches, Etudes et Techniques, Paris, France

(ISL-CO-243/88; ETN-90-96247) Avail: NTIS HC A03/MF A01

The problem of blade-vortex interaction is studied numerically and experimentally. Aerodynamic analysis is based on the computation of the velocity potential in a two dimensional, incompressible, inviscid and unsteady flow. It gives the instantaneous velocity field around a lifting Joukowski airfoil under the action of an incident vortex; pressure, lift and drag coefficients are deduced. Theoretical results are compared with measurements in a water tunnel where the vortex is generated by an oscillating airfoil upstream of the airfoil under study. A laser anemometer is used to measure the instantaneous vorticity field behind the first airfoil and a balance measures the forces acting on the receiving airfoil. Good agreement is found between measured and calculated lift coefficients. The aerodynamic analysis provides the inputs of an acoustic code. Two dimensional data are transformed to study the case of a parallel blade-vortex interaction of a helicopter rotor. The acoustic method is described and preliminary results are presented, showing some limitations of the technique. ESA

N90-18367# Aix-Marseilles Univ. (France). Inst. de Mecanique de la Turbulence.

AERODYNAMICS OF UNSTEADY SYSTEMS. NUMERICAL STUDY OF POTENTIAL FLOW/BOUNDARY LAYER COUPLING [AERODYNAMIQUE INSTATIONNAIRE: ETUDE NUMERIQUE DU COUPLAGE ECOULEMENT POTENTIEL/COUCHE LIMITE: RAPPORT D'AVANCEMENT DES TRAVAUX]

C. BEGUIER, P. FRAUNIE, A. MAATOUCH, and D. FOUSSEKIS Jun. 1989 87 p In FRENCH

(Contract DRET-82-272)

(ETN-90-96257) Avail: NTIS HC A05/MF A01

Software is developed for the two-dimensional calculation of the unsteady flow around a moving wing. The software allows the analysis of potential flow/boundary layer coupling, occurring under different cyclic movements such as helicopter rotors. The determination of the instantaneous pressure and flow velocity distribution on a moving wing are obtained. The results of the experiments carried out on a flat plate are given. The proposed coupling solution method seems to be to date the most suitable to describe the unsteady aerodynamic field around a moving wing. ESA

N90-18369# Bristol Univ. (England). Dept. of Aerospace Engineering.
OPTIMUM SPANWISE CAMBER FOR MINIMUM INDUCED DRAG
MARTIN V. LOWSON Nov. 1989 18 p
(BU-403; ETN-90-96286) Avail: NTIS HC A03/MF A01

Linear theory is used to develop optimum circulation distributions and their associated minimum induced drag for wakes from lifting surfaces with arbitrary spanwise camber. The work is largely computational, and results for cases previously investigated analytically are generally in good agreement. Some previously published results are found to be in error, and a new solution for the induced drag of a wing with dihedral is given. New results are computed for polynomial and superelliptic camber lines which may be of practical interest. An empirical correlation is demonstrated between the induced drag factor and the inverse arc length for a variety of optimum cases. Conclusions are given which suggest that the most effective form of camber for a given maximum displacement is the end plate, but elliptic and superelliptic shapes are slightly more effective in terms of minimum length of wing for a given displacement. ESA

N90-18370# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.). Hauptabt. Windkanale.
HALF MODEL TESTS ON AN ONERA CALIBRATION MODEL IN THE TRANSONIC WIND TUNNEL GOETTINGEN, FEDERAL REPUBLIC OF GERMANY
WOLFGANG LORENZ-MEYER May 1989 44 p In GERMAN; ENGLISH summary Report will also be announced as translation (ESA-TT-1195)
(DLR-MITT-89-20; ISSN-0176-7739; ETN-90-96275; ESA-TT-1195)
Avail: NTIS HC A03/MF A01; DLR, Wissenschaftliches Berichtswesen, Postfach 90 60 58, 5000 Cologne 90, Fed. Republic of Germany, 18.50 deutsche marks

Force and pressure distribution measurements in three wing sections are performed in the 1 m by 1 m transonic wind tunnel of the DLR using an ONERA calibration model. The model is mounted on the scale without a splitter-plate but with a 5 mm thick boundary layer trap. The results are compared to complete model tests carried out at ONERA and DLR. Standard wind tunnel correction is shown not to be sufficient for correcting half-model data. Flow visualization is obtained using oil-flow techniques. ESA

N90-18427# Vrije Univ., Brussels (Belgium). Dept. of Fluid Mechanics.
MEASUREMENT OF VELOCITY PROFILES AND REYNOLDS STRESSES ON AN OSCILLATING AIRFOIL
J. DERUYCK, B. HAZARIKA, and C. HIRSCH *In* AGARD, Unsteady Aerodynamic Phenomena in Turbomachines 15 p Feb. 1990
(Contract DAJA45-85-C-0039)
Copyright Avail: NTIS HC A14/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The flow around a sinusoidally oscillating NACA 0012 airfoil in the presence of the leading edge separation bubble and with leading edge stall, including laminar-turbulent transition is described. The airfoil oscillates about an axis at 25 percent chord from the leading edge, with a nominal reduced frequency of 0.3 and Reynolds number of 300,000. The experiments are made at 4 to 14 deg, 5 to 15 deg, 6 to 16 deg, and 8 to 18 deg angle of attack, covering flow conditions from no stall to full leading edge stall. It is found that the most probable cause of leading edge stall is due to the leading edge separation bubble burst and it occurs as soon as the static stall limit is exceeded. The leading edge stall is not due to the rapid upstream movement of the trailing edge separation. The velocity vectors and the Reynolds stress tensors are measured using a slanted rotating single sensor hot-wire. The complete suction side boundary layer profile and the near wake is surveyed at 5 to 15 deg oscillation where no interaction is observed between the leading edge and the trailing edge flows, and at 8 to 18 deg in full stall conditions. Author

N90-19193*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
STATIC INVESTIGATION OF A TWO-DIMENSIONAL CONVERGENT-DIVERGENT EXHAUST NOZZLE WITH MULTIAXIS THRUST-VECTORING CAPABILITY
JOHN G. TAYLOR Washington Apr. 1990 104 p
(NASA-TP-2973; L-16632; NAS 1.60:2973) Avail: NTIS HC A06/MF A01 CSCL 01/1

An investigation was conducted in the Static Test Facility of the NASA Langley 16-Foot Transonic Tunnel to determine the internal performance of two-dimensional convergent-divergent nozzles designed to have simultaneous pitch and yaw thrust vectoring capability. This concept utilized divergent flap rotation of thrust vectoring in the pitch plane and deflection of flat yaw flaps hinged at the end of the sidewalls for yaw thrust vectoring. The hinge location of the yaw flaps was varied at four positions from the nozzle exit plane to the throat plane. The yaw flaps were designed to contain the flow laterally independent of power setting. In order to eliminate any physical interference between the yaw flap deflected into the exhaust stream and the divergent flaps, the downstream corners of both upper and lower divergent flaps were cut off to allow for up to 30 deg of yaw flap deflection. The impact of varying the nozzle pitch vector angle, throat area, yaw flap hinge location, yaw flap length, and yaw flap deflection angle on nozzle internal performance characteristics, was studied. High-pressure air was used to simulate jet exhaust at nozzle pressure ratios up to 7.0. Static results indicate that configurations with the yaw flap hinge located upstream of the exit plane provide relatively high levels of thrust vectoring efficiency without causing large losses in resultant thrust ratio. Therefore, these configurations represent a viable concept for providing simultaneous pitch and yaw thrust vectoring. Author

N90-19194 Maryland Univ., College Park.
COMPUTATION OF HYPERSONIC UNSTEADY VISCOUS FLOW OVER A CYLINDER Ph.D. Thesis
YUNGHWAN BYUN 1988 176 p
Avail: Univ. Microfilms Order No. DA8912269

The purpose was to assess the time required to obtain the steady state and to study the physical nature of the transients during the unsteady approach to the steady state of the flow over an aerodynamic model in the impulsive hypersonic ground test facilities. Numerical simulation of the hypersonic viscous flow over a two dimensional circular cylinder in a shock tunnel has been attempted by using MacCormack's explicit time dependent predictor-corrector finite-difference method. The problem consists of two parts which are a quasi-one-dimensional nozzle flow for a convergent-divergent nozzle section and a flow over a circular cylinder for an aerodynamic model. The time dependent solution of the former has been used as the inflow boundary condition for the latter problem whose governing equations are two dimensional full Navier-Stokes equations. The flow is assumed as a calorically perfect gas and a laminar flow. For a nozzle flow, the start-up process of the shock tunnel and the time required to the steady state have been studied. For a flow over a cylinder, the transients at early time and the effects of the artificial damping terms and the outer boundary have been studied. Dissert. Abstr.

N90-19195 ESDU International Ltd., London (England).
CALCULATION OF EXCRESCENCE DRAG MAGNIFICATION DUE TO PRESSURE GRADIENT AT HIGH SUBSONIC SPEEDS
Aug. 1987 31 p
(ESDU-87004; ISBN-0-85679-597-6; ISSN-0141-4356) Avail: ESDU

This data item gives methods for estimating the factor by which the drag due to an isolated excrescence on a flat plate (for which ESDU 74036, 75031, 76008, 79015 and 84035 provide data) must be multiplied to obtain the drag implement when it is in a pressure gradient. The methods were developed theoretically by computing the change in drag of the aerofoil at constant lift when an increment of momentum thickness is introduced in the boundary layer calculation to represent the excrescence. The factor therefore includes the change in drag due to the incidence change made to keep the lift constant. Calculations were made for two airfoils, designed for high subsonic speeds, over a range of Mach number and incidence, and graphs show the dependence of the factor on lift and excrescence chordwise position, together with the corresponding pressure distributions on upper and lower surfaces. Since the magnification factor depends primarily on pressure gradient, estimating the factor for any other aerofoil requires only that a similar pressure gradient to that at the excrescence location be located on these graphs, and the corresponding magnification factor read. A second method of calculating the magnification factor is also given that depends on the flow properties at the excrescence location and at the trailing-edge. ESDU

N90-19196 Stanford Univ., CA.
UNSTEADY AERODYNAMICS OF DELTA WINGS PERFORMING MANEUVERS TO HIGH ANGLE OF ATTACK Ph.D. Thesis
MOHAMMAD-AMEEN MAHMO JARRAH 1989 295 p
Avail: Univ. Microfilms Order No. DA8912910

An experimental program of unsteady aerodynamic measurements motivated by maneuvers which have been proposed for agile fighter aircraft, was carried out. These tests were conducted in one of the 7 ft x 10 ft low speed wind tunnel at NASA on a series of flat delta wing models with sharp leading edges. By means of hydraulic actuation, rapid pitching motions were produced involving angle-of-attack excursions as great as 0 to 90 deg and back. These excursions involved sinusoidal or ramp variations in the angle of attack. Six-component airload histories were obtained for models of aspect ratios 1, 1.5, and 2. Flow visualization results were recorded using high speed cinematography for a model of aspect ratio one. Description of the apparatus and test procedures is presented. Over a range of reduced frequency parameter from 0.01 to 0.08, which is typical of these maneuvers, examples are given and discussed from the large body of data obtained. They include the unsteady response of the leading vortices, as evidenced both by the time dependent airloads and by motion pictures of smoke released from the leading edge and illuminated by a thin sheet of laser light. Unsteady vortex breakdown and reestablishment are emphasized. Dissert. Abstr.

N90-19197 California Univ., Berkeley.
INTERACTION OF AN OBLIQUE SHOCK WAVE WITH SUPERSONIC FLOW OVER A BLUNT BODY Ph.D. Thesis
YOUNG JUNE MOON 1988 139 p
Avail: Univ. Microfilms Order No. DA8916803

A numerical study of shock-on-shock interactions near a cylindrical body representative of the engine inlet cowl of the National AeroSpace Plane (NASP) is presented. Among the six principal interference patterns depending upon the intersection point, noted by Edney, the most critical cases, of types III and IV, were considered. In these cases, anomalous amplifications of peak pressure and heat flux occur at the shear layer and supersonic jet impingement points, respectively. The primary goal was to calculate the entire flow field numerically, capturing all the interacting shocks and complicated shock layer flows. Computational simulation of such flow with shocks and contact surfaces requires the use of a numerical scheme with monotonic properties in the Godunov sense, so as to avoid spurious oscillations near discontinuities. The fintie volume formulation of Van Leer's flux vector splitting MUSCL (Monotonic Upstream-centered Scheme for Conservation Laws) scheme, in generalized coordinates, was used to solve the full or thin layer Navier-Stokes equations in strong conservative form. The backward Euler implicit scheme with the approximate factorization method was used for time integration, since only the steady state solution is of interest. The present method was applied to the cases of supersonic blunt body flow, type III, III(+), and IV shock interference patterns. Here type III(+) is defined as a transitional stage of interference pattern changing from the type III to IV. For all cases, the present method captures complicated interacting shocks with monotonic properties and the anomalous pressures and heat fluxes compare reasonably well with experiments. Better agreement would be obtained if proper grid adaptations (grid enrichment algorithm) were employed. Dissert. Abstr.

N90-19198*# Notre Dame Univ., IN. Dept. of Aerospace and Mechanical Engineering.
LEADING EDGE VORTEX DYNAMICS ON A PITCHING DELTA WING M.S. Thesis
SCOTT P. LEMAY Apr. 1988 175 p
(Contract NAG1-727)
(NASA-CR-186327; NAS 1.26:186327) Avail: NTIS HC A08/MF A01 CSCL 01/1

The leading edge flow structure was investigated on a 70 deg flat plate delta wing which was pitched about its 1/2 chord position, to increase understanding of the high angle of attack aerodynamics on an unsteady delta wing. The wing was sinusoidally pitched at reduced frequencies ranging from k being identical with 2pi fc/u = 0.05 to 0.30 at chord Reynolds numbers between 90,000 and 350,000, for angle of attack ranges of alpha = 29 to 39 deg and alpha = 0 to 45 deg. The wing was also impulsively pitched at an approximate rate of 0.7 rad/s. During these dynamic motions, visualization of the leading edge vorticies was obtained by entraining titanium tetrachloride into the flow at the model apex. The location of vortex breakdown was recorded using 16mm high speed motion picture photography. When the wing was sinusoidally pitched, a hysteresis was observed in the location of breakdown position. This hysteresis increased with reduced frequency. The velocity of breakdown propagation along the wing, and the phase lag between model motion and breakdown location were also determined. When the wing was impulsively pitched, several convective times were required for the vortex flow to reach a steady state. Detailed information was also obtained on the oscillation of breakdown position in both static and dynamic cases. Author

N90-19199*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
WATER-TUNNEL INVESTIGATION OF CONCEPTS FOR ALLEVIATION OF ADVERSE INLET SPILLAGE INTERACTIONS WITH EXTERNAL STORES
DAN H. NEUHART (Lockheed Engineering and Sciences Co., Hampton, VA.) and MATTHEW N. RHODE Washington Apr. 1990 36 p
(NASA-TM-4181; L-16710; NAS 1.15:4181) Avail: NTIS HC A03/MF A01 CSCL 01/1

A test was conducted in the NASA Langley 16- by 24-Inch Water Tunnel to study alleviation of the adverse interactions of inlet spillage flow on the external stores of a fighter aircraft. A 1/48-scale model of a fighter aircraft was used to simulate the flow environment around the aircraft inlets and on the downstream underside of the fuselage. A controlled inlet mass flow was simulated by drawing water into the inlets. Various flow control devices were used on the underside of the aircraft model to manipulate the vortical inlet spillage flow. Author

N90-19201*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
A STREAMWISE UPWIND ALGORITHM APPLIED TO VORTICAL FLOW OVER A DELTA WING
PETER M. GOORJIAN and SHIGERU OBAYASHI Oct. 1989 13 p Presented at the 8th GAMM Conference on Numerical Methods in Fluid Mechanics, Delft, Netherlands, 27-29 Sep. 1989
(NASA-TM-102225; A-89230; NAS 1.15:102225) Avail: NTIS HC A03/MF A01 CSCL 01/1

Improvements were made to a streamwise upwind algorithm so that it can be used for calculating flows with vortices. A calculation is shown of flow over a delta wing at an angle of attack. The laminar, thin layer, Navier-Stokes equations are used for the calculation. The results are compared with another upwind method, a central differencing method, and experimental data. The present method shows improvements in accuracy and convergence properties. Author

N90-19202# Royal Aerospace Establishment, Farnborough (England).
A STUDY OF FLOWS OVER HIGHLY-SWEPT WINGS DESIGNED FOR MANEUVER AT SUPERSONIC SPEEDS
P. R. ASHILL, J. L. FULKER, and M. J. SIMMONS Oct. 1988 43 p
(AD-A216837; RAE-TM-AERO-2147; DRIC-BR-112012) Avail: NTIS HC A03/MF A01 CSCL 01/1

A wind tunnel investigation into supersonic free stream flows over two wing-body configurations, having wings of different design, suitable for combat aircraft, is described. Both wings have the same quasi-delta planform of 60 deg inboard leading edge sweep and the same 4 pct thickness distribution but have differing camber distributions. Following a description of the design of the wings, the test procedures are discussed and the general features of the flows at conditions close to those for sustained maneuver are identified and constrasted. Comparisons between calculations by CFD methods and measurement are presented, and it is shown that a multiblock method for solving the Euler equations is suitable for designing wings for efficient maneuver at supersonic speeds. Author

N90-19203*# Toledo Univ., OH. Dept. of Chemical Engineering.
HEAT TRANSFER MEASUREMENTS FROM A NACA 0012 AIRFOIL IN FLIGHT AND IN THE NASA LEWIS ICING RESEARCH TUNNEL M.S. Thesis Final Report
PHILIP E. POINSATTE Washington NASA Mar. 1990 194 p
(Contract NAG3-72)
(NASA-CR-4278; E-5228; NAS 1.26:4278) Avail: NTIS HC A09/MF A01 CSCL 01/1

Local heat transfer coefficients from a smooth and roughened NACA 0012 airfoil were measured using a steady state heat flux method. Heat transfer measurements on the specially constructed 0.533 meter chord airfoil were made both in flight on the NASA Lewis Twin Otter Research Aircraft and in the NASA Lewis Icing Research Tunnel (IRT). Roughness was obtained by the attachment of small, 2 mm diameter, hemispheres of uniform size to the airfoil surface in four distinct patterns. The flight data was taken for the smooth and roughened airfoil at various Reynolds numbers based on chord in the range of 1.24x10(exp 6) to 2.50x10(exp 6) and at various angles of attack up to 4 degrees. During these flight tests the free stream velocity turbulence intensity was found to be very low (less than 0.1 percent). The wind tunnel data was taken in the Reynolds number range of 1.20x10(exp 6) to 4.52x10(exp 6) and at angles of attack from -4 degrees to +8 degrees. The turbulence intensity in the IRT was 0.5 to 0.7 percent with the cloud making spray off. Results for both the flight and tunnel tests are presented as Frossling number based on chord versus position on the airfoil surface for various roughnesses and angle of attack. A table of power law curve fits of Nusselt number as a function of Reynolds number is also provided. The higher level of turbulence in the IRT versus flight had little effect on heat transfer for the lower Reynolds numbers but caused a moderate increase in heat transfer at the higher Reynolds numbers. Turning on the cloud making spray air in the IRT did not alter the heat transfer. Roughness generally increased the heat transfer by locally disturbing the boundary layer flow. Finally, the present data was not only compared with previous airfoil data where applicable, but also with leading edge cylinder and flat plate heat transfer values which are often used to estimate airfoil heat transfer in computer codes. Author

N90-19204*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THREE-DIMENSIONAL VISCOUS ROTOR FLOW CALCULATIONS USING A VISCOUS-INVISCID INTERACTION APPROACH
CHING S. CHEN and JOHN O. BRIDGEMAN (Woodside Summit Group, Inc., Mountain View, CA.) Feb. 1990 24 p Presented at the 15th European Rotorcraft Forum, Amsterdam, Netherlands, Sep. 1989 Submitted for publication
(NASA-TM-102235; A-89246; NAS 1.15:102235) Avail: NTIS HC A03/MF A01 CSCL 01/1

A three-dimensional viscous-inviscid interaction analysis was developed to predict the performance of rotors in hover and in forward flight at subsonic and transonic tip speeds. The analysis solves the full-potential and boundary-layer equations by finite-difference numerical procedures. Calculations were made for several different model rotor configurations. The results were compared with predictions from a two-dimensional integral method and with experimental data. The comparisons show good agreement between predictions and test data. Author

N90-19206*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DEVELOPMENT OF A PRELIMINARY HIGH-ANGLE-OF-ATTACK NOSE-DOWN PITCH CONTROL REQUIREMENT FOR HIGH-PERFORMANCE AIRCRAFT
LUAT T. NGUYEN and JOHN V. FOSTER (Lockheed Engineering and Sciences Co., Hampton, VA.) Feb. 1990 28 p
(NASA-TM-101684; NAS 1.15:101684) Avail: NTIS HC A03/MF A01 CSCL 01/1

The requirements for high-angle-of-attack nose-down pitch control for advanced high-performance aircraft are discussed. Background information on fundamental factors that influence and, to a large extent, determine the high angle-of-attack nose-down control requirement is briefly reviewed. Guidelines currently proposed by other sources which attempt to define these requirements are discussed. A requirement based on NASA analysis of the characteristics of existing relaxed static stability (RSS) aircraft is presented. This analysis could provide the basis for a preliminary design guide. Author

N90-19207# Technische Hochschule, Aachen (Germany, F.R.). Mathematisch-Naturwissenschaftlichen Fakultaet.
A PANEL PROCESS FOR THE CALCULATION OF THE FLOW AROUND A WING WITH FRONT ANGLE DAMPING Ph.D. Thesis [EIN PANELVERFAHREN ZUR BERECHNUNG DER STROEMUNG UM FLUEGEL MIT VORDERKANTENABLOESUNG: ZUR STETIGEN APPROXIMATION VON WIRBELSCHICHTEN]
KARLHEINZ HAAG 1988 93 p In GERMAN
(ETN-90-95367) Avail: NTIS HC A05/MF A01

The influence of free eddy layers, that appear in subsonic flows at the acute angles of the delta wings, on the aerodynamic values and the pressure distribution on the wing, is studied by means of a potential theoretical method. For the digital simulation, a panel process is used, with a total dipole distribution on the discontinuity layers. The nonlinear problem is dicretized and iteratively resolved by a collocation process; the Jacobi matrix is totally analytically calculated in the iteration process. The model is successfully tested for triangular wings, gothic wings, delta wings with vortex valves. By comparison with experiments and other calculation processes, good accordance with pressure distribution and aerodynamic values is obtained. In most described examples, there is no problem of convergence. ESA

N90-19208# Technische Hochschule, Aachen (Germany, F.R.). Fakultaet fuer Maschinenwesen.
CARRIER WING PROFILE IN NONSTATIONARY CURRENT Ph.D. Thesis [TRAGFLUEGELPROFILE IN INSTATIONAERER ANSTROEMUNG]
WILLI-BERT SCHWEITZER 1988 145 p In GERMAN
(ETN-90-95368) Avail: NTIS HC A07/MF A01

The nonstationary current profile is examined in the case of a constant angle of incidence and a time-dependent current velocity, in a water channel and a water gate and in an Eiffel wind channel, with laminar flows. To obtain a periodic, sinusoidal current, this channel is equipped with a rotating retaining valve of variable size, which produces variations of the flow velocity for a mean Reynolds number of 200,000. The turbulence degree of the current is very minimal and the higher harmonics cannot be avoided by any configuration. The measurement of nonstationary pressure distribution was made by means of a moving sonde in the water channel and the examination of the profile current in wind canal was realized by means of a helium wind generator. Both of the experiments showed some similar phenomena in the current processes, despite very different test conditions. ESA

N90-19211*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CONICAL EULER SOLUTION FOR A HIGHLY-SWEPT DELTA WING UNDERGOING WING-ROCK MOTION
ELIZABETH M. LEE and JOHN T. BATINA Mar. 1990 18 p
(NASA-TM-102609; NAS 1.15:102609) Avail: NTIS HC A03/MF A01 CSCL 01/1

Modifications to an unsteady conical Euler code for the free-to-roll analysis of highly-swept delta wings are described. The modifications involve the addition of the rolling rigid-body equation of motion for its simultaneous time-integration with the governing flow equations. The flow solver utilized in the Euler code includes a multistage Runge-Kutta time-stepping scheme which uses a finite-volume spatial discretization on an unstructured mesh made up of triangles. Steady and unsteady results are presented for a 75 deg swept delta wing at a freestream Mach number of 1.2 and an angle of attack of 30 deg. The unsteady results consist of forced harmonic and free-to-roll calculations. The free-to-roll case exhibits a wing rock response produced by unsteady aerodynamics consistent with the aerodynamics of the forced harmonic results. Similarities are shown with a wing-rock time history from a low-speed wind tunnel test. Author

N90-19213# National Aeronautical Lab., Bangalore (India). Computational and Theoretical Fluid Dynamics Div.
ANALYSIS AND DESIGN OF SYMMETRICAL AIRFOILS
P. RAMAMOORTHY and S. K. PRASAD Dec. 1989 21 p
(PD-CF-8943) Avail: NTIS HC A03/MF A01

A new theory is developed for the analysis and design of symmetrical airfoils. It is based on Lanczos polynomial interpolation and Goldsteins approximations to thick airfoil theory. The theory gave velocity, agreeing with the exact method of Theodorsen correct to three decimals. The inverse design part gave back the known airfoil coordinates again correct to three decimals. Author

03

AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

A90-27986#
DROPLET IMPACTION ON A SUPERSONIC WEDGE - CONSIDERATION OF SIMILITUDE
L. J. FORNEY (Georgia Institute of Technology, Atlanta) AIAA Journal (ISSN 0001-1452), vol. 28, April 1990, p. 650-654. Previously cited in issue 09, p. 1290, Accession no. A89-25567. refs
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A90-28179* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ICING RESEARCH TUNNEL TEST OF A MODEL HELICOPTER ROTOR
THOMAS L. MILLER and THOMAS H. BOND (NASA, Lewis Research Center, Cleveland, OH) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 367-378. refs
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An experimental program has been conducted in the NASA Lewis Research Center Icing Research Tunnel (IRT) in which an OH-58 tail rotor assembly was operated in a horizontal plane to simulate the action of a typical main rotor. Ice was accreted on the blades in a variety of rotor and tunnel operating conditions and documentation of the resulting shapes was performed. Rotor torque and vibration are presented as functions of time for several representative test runs, and the effects of various parametric variations on the blade ice shapes are shown. This OH-58 test was the first of its kind in the United States and will encourage additional model rotor icing tunnel testing. Although not a scaled representative of any actual full-scale main rotor system, this rig has produced torque and vibration data which will be useful in assessing the quality of existing rotor icing analyses. Author

A90-28180* Army Aviation Engineering Flight Activity, Edwards AFB, CA.
INITIAL RESULTS FROM THE JOINT NASA-LEWIS/U.S. ARMY ICING FLIGHT RESEARCH TESTS
DAUMANTS BELTE (U.S. Army, Aviation Engineering Flight Activity, Edwards AFB, CA) and RICHARD J. RANAUDO (NASA, Lewis Research Center, Cleveland, OH) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 379-392. refs
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The U.S. Army/NASA joint testing of the various aspects of in-flight and ground-based icing simulation facilities and instrumentation is reviewed. The NASA DN-6 icing research aircraft, the U.S. Army JU-21A aircraft, the portable spray rig, helicopter icing spray system, and icing research tunnel are examined. Natural and artificial icing tests, turbulence measurements, and calibration and icing research tunnel tests are described and test results are reported. C.D.

A90-28182* Boeing Helicopter Co., Philadelphia, PA.
DEVELOPMENT OF THE IMPROVED HELICOPTER ICING SPRAY SYSTEM (IHISS)
ANDREW A. PETERSON, MARK D. JENKS (Boeing Helicopters, Philadelphia, PA), and WILLIAM H. GAITSKILL (U.S. Army, Aviation Systems Command, Saint Louis, MO) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 401-412. Research supported by NASA. refs
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Boeing Helicopters has been awarded a contract by the U.S. Army to design, fabricate and test a replacement for the existing Helicopter Icing Spray System (HISS). The Improved Hiss (IHISS), capable of deployment from any CH-47D helicopter, will include new icing spray nozzles and pneumatic pressure source, and a significantly larger water tank and spray boom. Results are presented for extensive bench and icing tunnel test programs used to select and modify an improved spray nozzle and validate spray boom aerodynamic characteristics. The resulting system will provide a significantly larger icing cloud with droplet characteristics closely matching natural icing conditions. Author

A90-29803
HIGH-PERFORMANCE PARACHUTES
CARL W. PETERSON (Sandia National Laboratories, Albuquerque, NM) Scientific American (ISSN 0036-8733), vol. 262, May 1990, p. 108-111, 115, 116. refs
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The development of high-perfomance parachutes to quickly decelerate a capsule from supersonic speeds is examined. Consideration is given to simulation studies, high-strength materials such as kevlar, and advanced design techniques. The airflows of parachute inflation and of a ribbon parachute traveling at supersonic speed are illustrated. The Canopy Loads Analysis and LINESAIL computer programs are discussed. The B83 parachute system, which can decelerate from 1,000 km/h to 85 km/h in four seconds while descending 45 m, is described. R.B.

A90-30587
WHY BIRDS KILL - CROSS-SECTIONAL ANALYSIS OF U.S. AIR FORCE BIRD STRIKE DATA
JAY C. NEUBAUER (USAF, School of Aerospace Medicine, Brooks

AFB, TX) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 61, April 1990, p. 343-348. refs
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This is a cross-sectional analysis of 22,423 bird strikes reported in the U.S. Air Force in 1974-88. Summary statistics revealed patterns previously reported by others. Relative risk analysis of fatal and injurious bird strikes revealed several statistically significant associations. Fatal or injurious outcomes were associated with strikes in the F-4 and B-1. In addition, windshield penetration was likely to cause death or injury. Flying on a bombing range or flying at speeds greater than 556 km/h were also more likely to lead to a serious outcome. Author

A90-31285#
ELASTIC-VISCOPLASTIC FINITE-ELEMENT PROGRAM FOR MODELING TIRE/SOIL INTERACTION
JOSEPH E. SALIBA (Dayton, University, OH) Journal of Aircraft (ISSN 0021-8669), vol. 27, April 1990, p. 350-357. Research sponsored by USAF. refs
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The viscoplastic finite-element program for modeling tire/soil interaction is shown to be a powerful analytical tool that has a significant promise for improving the Air Force ability to predict aircraft ground operation. A brief review of the mathematical theory of viscoplasticity and the computational procedure used in the finite-element program is first presented. Next, some of the capabilities of this powerful analytical tool are demonstrated. The first example considered is that of the effect of tire pressure on sinkage and rut depth produced on constant strength clay and sand soils. Then, the effect of layered soil on sinkage and rut depth is examined, considering the possibility of soft over hard as well as of hard over soft layers. This latest case is further studied investigating the effect of the variation of the top thickness layer or sinkage. In conclusion, tables are presented that provide an equivalent cone index for a two-layered clay soil of different strengths and thickness. To demonstrate the capability of the program to model contingency surfaces, the behavior of standard flexible and rigid pavements under a medium tire pressure were considered. Author

A90-31335
UNDERLYING FACTORS IN AIR TRAFFIC CONTROL INCIDENTS
PAUL STAGER, DONALD HAMELUCK, and REBECCA JUBIS (York University, Toronto, Canada) IN: Human Factors Society, Annual Meeting, 33rd, Denver, CO, Oct. 16-20, 1989, Proceedings. Volume 1. Santa Monica, CA, Human Factors Society, 1989, p. 43-46. Research supported by Transport Canada. refs
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As part of a continuing investigation of the conditions associated with operating irregularities in air traffic control (ATC), reports prepared during the investigation of 301 operating irregularities were analyzed in order to identify the factors most likely to precipitate air traffic control incidents. Operating irregularities were found to occur more frequently under conditions of moderate or low workload and normal complexity. A second objective of the work has been to develop a database system from which statistical data on operating irregularities and the various identified factors can be extracted. However, in order to enhance the integrity of the descriptive information in the database, the category structure that has been used to record the occurrence of ATC incidents is being revised to reflect the contemporary approaches to human error. A brief description of the proposed structure is included in the present paper. Author

A90-31388
AFTER HABSHEIM
DAVID LEARMOUNT Flight International (ISSN 0015-3710), vol. 137, April 11, 1990, p. 32-35.
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The paper reviews the Airbus A320 accident in France that raised the question of fly-by-wire's protective capacity. It is noted that pilots know they can fly safely to the A320's flight envelope's limits, but exactly what those limits are must still be determined. Though the official technical report of the Investigation Commission exonerated the aircraft, controls, and engines, putting all the blame on the flight crew, some pilots are still not prepared to relax with the A320. Particular attention is paid to the fact that the aircraft was performing a demonstration flyby under operating conditions not normally flown during regular commercial operations. Pertinent technical details from the Investigation Commission's report are provided, along with a brief mention of the A320 landing accident that occurred in India about nine months later during a scheduled flight. R.E.P.

N90-18371*# Environmental Research Inst. of Michigan, Ann Arbor.
SYNTHETIC APERTURE RADAR IMAGERY OF AIRPORTS AND SURROUNDING AREAS: ARCHIVED SAR DATA Final Report, 31 Aug. 1987 - 30 Nov. 1989
ROBERT G. ONSTOTT and DENISE J. GINERIS Washington NASA Feb. 1990 214 p
(Contract NAS1-18465)
(NASA-CR-4275; NAS 1.26:4275; DOT/FAA/DS-89/14) Avail: NTIS HC A10/MF A02 CSCL 17I

The statistical description of ground clutter at an airport and in the surrounding area is addressed. These data are being utilized in a program to detect microbursts. Synthetic aperture radar (SAR) data were acquired from the ERIM SAR data archive and were examined for utility to this program. Eight digital scattering coefficient images were created of five airports. These data are described along with the results of the clutter study. These scenes were imaged at 9.38 GHz and HH- and VV-polarizations and contained airport grounds and facilities, industrial, residential, fields, forest, and water. Incidence angles ranged from 12 to 72 deg. Even at the smallest incidence angles, the distributed targets such as forest, fields, water, and residential rarely had mean scattering coefficients greater than -10 dB. Eighty-seven percent of the image had scattering coefficients less than -17.5 dB. About 1 percent of the scattering coefficients exceeded 0 dB, with about 0.1 percent above 10 dB. Sources which produced the largest cross sections were largely confined to the airport grounds and areas highly industrialized. The largest cross sections were produced by observing large buildings surrounded by smooth surfaces. Author

N90-18372*# Environmental Research Inst. of Michigan, Ann Arbor.
SYNTHETIC APERTURE RADAR IMAGERY OF AIRPORTS AND SURROUNDING AREAS: PHILADELPHIA AIRPORT Final Report, 31 Aug. 1987 - 30 Nov. 1989
ROBERT G. ONSTOTT and DENISE J. GINERIS Mar. 1990 108 p
(Contract NAS1-18465)
(NASA-CR-4280; NAS 1.26:4280; DOT/FAA/DS-89/15) Avail: NTIS HC A06/MF A01 CSCL 01C

The statistical description of ground clutter at an airport and in the surrounding area is addressed. These data are being utilized in a program to detect microbursts. Synthetic Aperture Radar (SAR) data were collected at the Philadelphia Airport. These data and the results of the clutter study are described. This 13 km x 10 km scene was imaged at 9.38 GHz and HH-polarization and contained airport grounds and facilities (6 percent), industrial (14 percent), residential (14 percent), fields (10 percent), forest (8 percent), and water (33 percent). Incidence angles ranged from 40 to 84 deg. Even at the smallest incidence angles, the distributed targets such as forest, fields, water, and residential rarely had mean scattering coefficients greater than -10 dB. Eighty-seven percent of the image had scattering coefficients less than -17.5 dB. About 1 percent of the scattering coefficients exceeded 0 dB, with about 0.1 percent above 10 dB. Sources which produced the largest cross sections were largely confined to the airport grounds and areas highly industrialized. The largest cross sections were produced by observing broadside large buildings surrounded by smooth surfaces. Author

N90-18373# Federal Aviation Administration, Washington, DC.
NATIONAL AIRSPACE SYSTEM PLAN: FACILITIES, EQUIPMENT, ASSOCIATED DEVELOPMENT AND OTHER CAPITAL NEEDS Annual Report
Sep. 1989 380 p
(AD-A215882) Avail: NTIS HC A17/MF A02 CSCL 17/7

The National Airspace System (NAS) is the busiest and most complex in the world. It is a mixture of equipment, techniques, and skills that has evolved over 50 years. Without question, it is the world's safest and most efficient, yet, at the outset of this plan, its expansion capability was limited and adaptability to changing requirements was difficult. Aviation activity is forecast to increase substantially over the next two decades. Continuing growth in the number of aircraft operations, number of aircraft, enplanements, diversity of operations, DOD operations and sophistication of aircraft will place unprecedented demands on the NAS. Meeting this challenge requires improved and expanded services, additional facilities and equipment, improved work force productivity, and the orderly replacement of aging equipment. In December, 1981, the Federal Aviation Administration (FAA) chartered a comprehensive NAS Plan for modernizing and improving air traffic control and airway facilities services through the year 2000. This is the seventh annual update of the NAS Plan. The Plan addresses the compelling problems of how best to improve safety and efficiency, accommodate spiraling demands for aviation services, deal with the problems of aging or obsolete facilities, recognize the users desires for minimal restrictions on the use of the airspace, allow for a reduced Federal role, and create a foundation for continued evolution which exploits newer technologies and developments. GRA

N90-18375# Dayton Univ., OH. Structural Integrity Div.
STUDY OF BIRD INGESTIONS INTO SMALL INLET AREA, AIRCRAFT TURBINE ENGINES (MAY 1987 TO APRIL 1988) Interim Report
JOSEPH P. MARTINO and DONALD A. SKINN Atlantic City, NJ FAA Dec. 1989 70 p
(Contract DTFA03-88-C-00024)
(DOT/FAA/CT-89/17; UDR-TR-89-03) Avail: NTIS HC A04/MF A01

The Federal Aviation Administration Technical Center initiated a study to determine the numbers, sizes, and types of birds which are being ingested into small inlet area turbofan and turbine engines and to determine what damage, if any, results. Bird ingestion data are being collected for the ALF502, TFE731, and TPE331 engines. The first of 2 years of data collection is analyzed. Author

N90-18376# Centre d'Essais Aeronautique Toulouse (France). Lab. Essais d'Impacts sur Structures.
BIRD IMPACT TESTS ON A KEVLAR 49 STRUCTURE. MONOLITHIC PLATES. OBLIQUE-ANGLED IMPACT Partial Test Report No. 2 [ESSAIS D'IMPACTS D'OISEAUX SUR STRUCTURE KEVLAR 49. PLAQUES MONOLITHES-TIRS OBLIQUES. PROCES-VERBAL S3-4273 PARTIEL NO. 2]
6 Jul. 1988 51 p In FRENCH
(REPT-S3-4273; CEAT-NT-10/S/83; ETN-90-96258) Avail: NTIS HC A04/MF A01

The results of experiments concerning the impacts of 4 pound birds on flat rectangular and square monolithic Kevlar 49 plates are reported. Projectile trajectories and different angles of attack are investigated. It is observed that the painted coating used for protecting Kevlar 49 surfaces improves the sliding of the birds over the surface after the impact. The results show that the impact energy perpendicular to the surface is lower in the oblique-angled shot than in the normal shot and remains lower than the piercing energy. ESA

N90-19215# Sandia National Labs., Albuquerque, NM. Experimental Mechanics Dept.
HELICOPTER FLIGHT VIBRATION OF LARGE TRANSPORTATION CONTAINERS: A CASE FOR TESTING TAILORING
J. D. ROGERS, D. B. BEIGHTOL, and J. W. DOGGETT 1989 7 p Presented at the 36th Institute of Environmental Science Annual Technology Meeting, New Orleans, LA, 23-27 Apr. 1990
(Contract DE-AC04-76DP-00789)
(DE90-007429; SAND-89-2140C; CONF-900479-4) Avail: NTIS HC A02/MF A01

A testing situation is described in which the test specification was derived from MIL-STD-810D for helicopter flight vibration of some test items. The items were to be inside two very large transportation containers (masses on the order of 2000 to 4000 pounds). Severe testing difficulties were anticipated in achieving the desired levels from the test specification. It was then decided to obtain appropriate field data to modify the test specification. The data were obtained during flights of CH-47D helicopters containing the transportation containers. The vibration levels experienced by the test items were significantly below those specified in the original test plan. DOE

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

A90-27781
AN ARRAY-FED REFLECTOR ANTENNA WITH BUILT-IN CALIBRATION FACILITY
A. PEARSON, C. D. MCEWEN (STC Technology, Ltd., Harlow, England), S. J. DEAN, and R. WEBB (STC Defence Systems, Paington, England) IN: International Conference on Antennas and Propagation (ICAP 89), 6th, Coventry, England, Apr. 4-7, 1989, Proceedings. Part 1. London, England and Piscataway, NJ, Institution of Electrical Engineers, 1989, p. 28-31.
Copyright

An eight-element array-fed reflector antenna has been designed and built for use with an experimental low-angle tracking radar. The radar is to evaluate signal processing algorithms which improve elevation accuracy under the severe multipath conditions that exist for targets flying low over the sea. The antenna design and principal design parameters, antenna construction, and calibration system are described. C.D.

A90-27875
A BEARING ERROR IN THE VHF OMNIRANGE DUE TO SEA SURFACE REFLECTION
K. YAMAMOTO and M. NAGAOKA (Ministry of Transport, Tokyo, Japan) IN: International Conference on Antennas and Propagation (ICAP 89), 6th, Coventry, England, Apr. 4-7, 1989, Proceedings. Part 2. London, England and Piscataway, NJ, Institution of Electrical Engineers, 1989, p. 181-185. refs
Copyright

The bearing error of the SSB-DVOR by sea surface reflection is analyzed. It is shown that the error is mainly due to the variation of the intrinsic station error, which is caused by the eccentricity effect of the counterpoise. Thus, the magnitude of the error depends on the azimuth angle of the aircraft and the size of the counterpoise. The error does not occur at the course where the intrinsic error does not appear. The larger the counterpoise becomes, the less the variation of the bearing, since the intrinsic error also decreases. A numerical expression for the intrinsic error is shown to be directly applicable for predicting the VOR course error. The method can be used to evaluate the bearing error for the station installed close to seashore, and may be extended to problems involving higher-order error. C.D.

A90-27922
OUR FUTURE AIR NAVIGATION SYSTEM EMBODIES A GLOBAL CONCEPT
BRIAN O'KEEFFE (Civil Aviation Administration, Australia) ICAO

Bulletin (ISSN 0018-8778), vol. 44, Sept. 1989, p. 15-18.
Copyright

The work of the Future Air Navigation Systems (FANS) Committee is reviewed. It has developed a system concept for communication, navigation, and surveillance (CNS), together with the evolution of air traffic management, to overcome the limitations of the existing system, and to meet the needs of aviation on a global scale into the 21st century in a cost-effective manner. FANS first carried out an assessment of the capabilities (and the shortcomings) of the present systems, and of their implementation in various parts of the world. The development of the FANS system concept will give aviation administrations access to satellite CNS systems, to provide services in their areas of responsibility. The FANS committee notes that it is of vital interest to international civil aviation to secure internationally coordinated evolution and transition. Thus, it is concluded that the ICAO must be involved in these global system developments. R.E.P.

A90-27923
INSTITUTIONAL STEPPING STONES FOR FANS
R. F. NORTH (Transport Canada, Ottawa) ICAO Bulletin (ISSN 0018-8778), vol. 44, Sept. 1989, p. 22-25.
Copyright

A summary is presented of the institutional steps first presented to the Working Group of the Future Air Navigation Systems (FANS) Committee, accomplishments to date, and the future implementation of a viable satellite-based aeronautical mobile satellite service. The inadequacies of the basic current civil aviation long distance mobile communication system, HF/VHF, are described. It is pointed out that an important part of the institutional arrangements should be the basic provisions required to ensure a continuing and adequate monitoring of the system performance to avoid rundown and obsolescence in the future. Conformation to ICAO Standards and Recommended Practices (SARP) and Procedures is a vital requirement for satisfactory operation. It is noted that the past two decades show that there has been development both in technology and in the emergence of institutions to make use of the technology, to provide a worldwide aeronautical mobile satellite system within the next decade. R.E.P.

A90-27924
PROSPECTS ARE VERY GOOD FOR USING SATELLITES FOR AERONAUTICAL NAVIGATION
T. G. ANODINA (International Scientific Experimental Air Traffic Control Centre, USSR) ICAO Bulletin (ISSN 0018-8778), vol. 44, Sept. 1989, p. 29-31.
Copyright

Research and development of the U.S. GPS and the Global Navigation Satellite System (GLONASS) of the USSR are described. It is noted that these systems have much in common in their composition and technical characteristics, but they also have some differences. Both systems provide similar determination accuracies for coordinates (100 m), for altitude (150 m), for time correction (1 microsecond for GLONASS and 385 ns for GPS). Combining the major attributes of these two systems has been proposed and the benefits to be realized are presented. It is concluded that particularly important is the increase in the integrity of the combined system and in the reliability of the navigation determinations. This will be achieved not only as a result of the improvement in the monitoring of navigation satellite signals when using the monitoring stations of both systems but also, mainly, as a result of navigation satellites in the user's area of view. R.E.P.

A90-27925
ARSR-4 LONG RANGE RADAR WILL UPGRADE U.S. EN-ROUTE SURVEILLANCE
JOHN A. HUNTER, KENNETH J. LEE, and MARGARET M. LORD (Westinghouse Electric Corp., Pittsburgh, PA) ICAO Bulletin (ISSN 0018-8778), vol. 44, Sept. 1989, p. 32-36.
Copyright

The ARSR-4 surveillance radar program initiated by the FAA in 1988 is presented. This system is designed to provide three-dimensional, unattended radar coverage capable of detecting small aircraft in all weather conditions. These state-of-the-art radar systems will replace aging, manpower-intensive radar systems and provide vital surveillance for en route air traffic control. Performance upgrades provided by the ARSR-4 include increased range coverage, improved weather detection and reporting, and lower throughput response time. It is noted that where several alternative designs could be implemented without performance or cost impact, a choice was made to favor that design which facilitated a growth capability. R.E.P.

A90-28219* Systems Technology, Inc., Mountain View, CA.
FULLY AUTOMATIC GUIDANCE FOR ROTORCRAFT NAP-OF-THE-EARTH (NOE) FLIGHT FOLLOWING PLANNED PROFILES
PETER J. GORDER, WARREN F. CLEMENT, and WAYNE F. JEWELL (Systems Technology, Inc., Mountain View, CA) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 891-899. refs
(Contract NAS2-12640)
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Developing a single-pilot, all-weather nap-of-the-earth (NOE) capability requires fully automatic NOE navigation and flight control. Innovative guidance and control concepts are being investigated in a fourfold research effort that will culminate in the real-time piloted simulation of promising alternatives for automatic guidance and control of rotorcraft in NOE operations, thereby providing a practical demonstration for evaluating pilot acceptance of the automated concepts. Author

A90-28839
MCDONNELL DOUGLAS HELICOPTER COMPANY APACHE TELEMETRY ANTENNA ANALYSIS
TROY GAMMILL IN: ITC/USA/'89; Proceedings of the International Telemetering Conference, San Diego, CA, Oct. 30-Nov. 2, 1989. Research Triangle Park, NC, Instrument Society of America, 1989, p. 179-187.
Copyright

An analysis has been conducted of the AH-64 Apache helicopter's telemetry antenna patterns in order to remedy the high data dropout encountered during the helicopter's maneuvering on the test range. Advanced software was applied to the analysis effort, with a view to identifying a superior antenna configuration and antenna location on the aircraft. The basic problem involved the large blockage in the monopole antenna's radiation pattern due to the location of the telemetry antenna; coverage was improved by simply adding another antenna to the helicopter's vertical stabilizer. O.C.

A90-29655
OPERATING PRINCIPLES OF A TERRAIN-RECOGNITION AIR NAVIGATION SYSTEM [PRINCIPY CINNOSTI SYSTEMU ROZPOZNAVACI LETECKE NAVIGACE]
JAROSLAV KOKULUS Zpravodaj VZLU (ISSN 0044-5355), no. 1, 1990, p. 15-20. In Czech. refs
Copyright

The paper discusses the operating principles of the SRLN terrain-recognition air navigation system when flying at low altitudes above a complex terrain. Examples of potential sources of navigation information are presented, and two terrain-recognition systems using terrain elevation profiles a given distance from the aircraft are described. B.J.

A90-30688
A POWERFUL RANGE-DOPPLER CLUTTER REJECTION STRATEGY FOR NAVIGATIONAL RADARS
T. K. BHATTACHARYA and P. R. MAHAPATRA (Indian Institute of Science, Bangalore, India) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 132-137. refs
Copyright

The author describe a method to combat arbitrary delay-Doppler clutter. The problem is approached using the signal ambiguity function. A matched filter receiver is assumed and transmitted signal parameters are optimized to achieve the clutter rejection capability. The signal set chosen is the family of frequency-coded constant-amplitude pulse bursts, and a criterion function is derived in terms of the frequencies of individual subpulses. The proposed method optimizes the detection performance of the radar for any given clutter distribution in the delay-Doppler plane of the radar. Representative results are presented which show the ambiguity function for optimum FSK (frequency-shift-keying) bursts for different burst lengths and clutter distributions. The results obtained clearly bring out the effectiveness of the method. I.E.

A90-30693
ACCURATE ILS AND MLS PERFORMANCE EVALUATION IN PRESENCE OF SITE ERRORS
PRAVAS R. MAHAPATRA (Indian Institute of Science, Bangalore, India) and M. M. POULOSE (National Airports Authority of India, Bangalore) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 167-174. refs
Copyright

A powerful and versatile analytical approach is outlined for performing the site evaluation of instrument landing systems (ILS) and microwave landing systems (MLS) without resorting to the current experimental methods. The problem is treated as one of scattering, using a ray-theoretic approach. A multiwedge model of the terrain ahead of the antenna assembly is generated from standard survey data and an exact ray-tracing procedure is evolved to trace all the rays between the antenna elements and approaching aircraft. The power of the current uniform diffraction theory (UTD) to evaluate scattered fields from wedges is extended to include the impedance and roughness of the wedge, and the theory is applied to the multiwedge terrain model for evaluating the field. The results are reduced to a form compatible with ICAO (International Civil Aviation Organization) specified tests and compared with experimental data from real airports. I.E.

A90-30695
ANALYTICAL EVALUATION OF RADIATION PATTERNS OF A TACAN ANTENNA
M. C. CHANDRA MOULY, K. SATYA SUNANDA, and K. VASANTHA LAKSHMI (V.R. Siddhartha Engineering College, Vijayawada, India) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 187-192. refs
Copyright

The authors present a method for the analytical evaluation of the radiation patterns of a TACAN (tactical air navigation) antenna, based on image theory. The discone antenna utilized in TACAN gives an omni pattern in the horizontal plane. A single lobe caused by the inner parasitic and nine lobes arising due to the outer parasitics together effectively enable coarse and fine bearing measurements. Since the inner and outer parasitics are both rotated at 15 rev/s, the nine-lobed pattern rotates in space at a 15-Hz rate. I.E.

A90-30752#
AUTOMATED MEASUREMENT OF AIRCRAFT-LEVEL ELECTROMAGNETIC INTERFERENCE
STEVEN C. COFFMAN and KATHRYN J. MEDLEY (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 981-987.

Automated testing for electromagnetic compatibility (EMC), which allows continuous sweeping across all frequency bands at sensitivities below -120 dBm in a timely manner, is addressed. This method eliminates frequency gaps and reveals interference that may have been missed by the previous EMC testing method. It also identifies each signal and its corresponding magnitude. The method accurately determines the frequency, amplitude, and modulation type at the input to the receiver. With this information, it is known whether significant degradation in the victim receiver will occur and, if so, its extent. Data from an aircraft test show that equipment that does not meet MIL-STD-461C REO2 emissions requirements in the radio band generally causes interference to the receiver. Often the interference is not detected during a radio check but does degrade the operational range of the receiver. This result indicates that the current REO2 limits are realistic and should be strictly enforced. I.E.

A90-30790
B-1B DOPPLER ERROR COMPENSATION BASED ON FLIGHT DATA ANALYSIS
DANIEL O. MOLNAR and JOHN PATTERSON (Boeing Military Airplanes, Seattle, WA) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 4. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 1753-1757.
Copyright

Numerous B-1B flight tests with good tracking reference data have made possible a new level of Doppler error analysis. The analysis involves the fitting of the Doppler error data to aircraft dynamics data. Reference velocity truth is provided by the Northrop Astro Inertial System (NAIS). The Doppler errors are expressed as scale factor and bore sight errors. Doppler and NAIS velocity are recorded together with dynamics data. The dynamics data are used as independent variables in attempts to model the observed Doppler errors. A modified group method of data handling (GMDH) procedure is used for automated search over thousands of possible models. The Akaike information criterion is used to select the best polynomial fit and avoid fitting to noise. Past attempts to determine the error models for the common strategic Doppler were limited to relatively few different structures. However, with the advent of GMDH, more exhaustive search for cause-and-effect relationships has become possible. The basic GMDH method and extensions are described. I.E.

A90-31334
CONSIDERATIONS OF NOISE FOR THE USE OF COMPRESSED SPEECH IN A COCKPIT ENVIRONMENT
LORRI J. CRITTENDEN, NEWTON C. ELLIS, and RODGER J. KOPPA (Texas A & M University, College Station) IN: Human Factors Society, Annual Meeting, 33rd, Denver, CO, Oct. 16-20, 1989, Proceedings. Volume 1. Santa Monica, CA, Human Factors Society, 1989, p. 38-42. refs
Copyright

This research investigated the feasibility of using time compressed speech in a cockpit environment by examining the effect of cockpit noise on the intelligibility and comprehensibility of compressed speech. Research participants listened to cockpit-oriented verbal messages and were required to write them down afterwards. Results revealed a significant difference in compression levels between the environment without the ambient cockpit noise and the noise environment. The primary finding of this study was an interaction between noise and compression level. Implications of this research are made for the design of advanced crew systems. Author

N90-18378*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DELIVERY PERFORMANCE OF CONVENTIONAL AIRCRAFT BY TERMINAL-AREA, TIME-BASED AIR TRAFFIC CONTROL: A REAL-TIME SIMULATION EVALUATION
LEONARD CREDEUR, JACOB A. HOUCK, WILLIAM R. CAPRON, and GARY W. LOHR (Embry-Riddle Aeronautical Univ., Daytona Beach, FL.) Washington Apr. 1990 66 p
(NASA-TP-2978; L-16615; NAS 1.60:2978) Avail: NTIS HC A04/MF A01 CSCL 17/7

A description and results are presented of a study to measure the performance and reaction of airline flight crews, in a full workload DC-9 cockpit, flying in a real-time simulation of an air traffic control (ATC) concept called Traffic Intelligence for the Management of Efficient Runway-scheduling (TIMER). Experimental objectives were to verify earlier fast-time TIMER time-delivery precision results and obtain data for the validation or refinement of existing computer models of pilot/airborne performance. Experimental data indicated a runway threshold, interarrival-time-error standard deviation in the range of 10.4 to 14.1 seconds. Other real-time system performance parameters measured include approach speeds, response time to controller turn instructions, bank angles employed, and ATC controller message delivery-time errors. Author

N90-18380# Federal Aviation Administration, Atlantic City, NJ.
DALLAS/FORT WORTH SIMULATION. VOLUME 2: APPENDIXES D, E, AND F
LLOYD HITCHCOCK, LEE E. PAUL, EPHRAIM SHOCKET, and RICHARD D. ALGEO Nov. 1989 289 p
(AD-A216613; DOT/FAA/CT-TN89/28-VOL-2) Avail: NTIS HC A13/MF A02 CSCL 01/5

A series of dynamic, real time, air traffic control simulations of selected aspects of the D/FW Metroplex Air Traffic System Plan were conducted. Using D/FW controllers as subjects, the simulations provided an opportunity to evaluate proposed changes in area flow patterns and traffic management and to experience simultaneous approaches to the four parallel runway configuration under consideration for D/FW. The results of these simulations demonstrated that, even when faced with up to twice their normal traffic load, the controllers could maintain a smooth and safe flow of traffic using the new configurations proposed for the D/FW area. The D/FW Evaluation Team declared that the parallel arrival routes, separate altitudes for high performance turboprops, increased departure routes, and stratified sectors all proved to be valuable controller tools. In addition, simulation of the four simultaneous parallel approaches led to the Evaluation Team to enthusiastically endorse the concept of four simultaneous approaches to the D/FW airport and to affirm that in each and every case the concept proved to be safe even though frequently challenged by the unlikely conditions of 30 degree blunders without communications. GRA

N90-18383# Test Group (6585th), Holloman AFB, NM.
THE FOURTEENTH BIENNIAL GUIDANCE TEST SYMPOSIUM, VOLUME 1
30 Oct. 1989 495 p Symposium held in Holloman AFB, NM, 3-5 Oct. 1989
(AD-A216925; MSD-TR-89-21-VOL-1) Avail: NTIS HC A21/MF A03 CSCL 17/7

This symposium was directed toward the exchange of information, simulation of new ideas, and discussion of current techniques associated with the development and evaluation of inertial guidance and navigation systems. The papers presented included such topics as new test and calibration techniques for accelerometers and ring laser gyros, advances in flight reference systems, new test equipment, and new software developments. GRA

N90-19217# Sandia National Labs., Albuquerque, NM.
HELI/SITAN: A TERRAIN REFERENCED NAVIGATION ALGORITHM FOR HELICOPTERS
JEFF HOLLOWELL 1990 10 p Presented at PLANS 90, Las Vegas, NV, 20-23 Mar. 1990
(Contract DE-AC04-76DP-00789; AVRADA PROJ. 5620112DA)
(DE90-005193; SAND-89-1972C; CONF-900372-1) Avail: NTIS HC A02/MF A01

Heli/SITAN is a Terrain Referenced Navigation (TRN) algorithm that utilizes radar altimeter ground clearance measurements in combination with a conventional navigation system and a stored digital terrain elevation map to accurately estimate a helicopter's position. Multiple Model Adaptive Estimation (MMAE) techniques are employed using a bank of single state Kalman filters to ensure that reliable position estimates are obtained even in the face of large initial position errors. A real-time implementation of the algorithm was tested aboard a U.S. Army UH-1 helicopter equipped with a Singer-Kearfott Doppler Velocity Sensor (DVS) and a Litton LR-80 strapdown Attitude and Heading Reference System (AHRS). The median radial error of the position fixes provided in real-time by this implementation was less than 50 m for a variety of mission profiles. DOE

N90-19223# Air War Coll., Maxwell AFB, AL.
INTEROPERABILITY ISSUES IN THE USE OF SATELLITE-BASED NAVIGATION SYSTEMS FOR CIVIL AVIATION PURPOSES
MARCOS COSTILLA May 1989 88 p
(AD-A217279) Avail: NTIS HC A05/MF A01 CSCL 17/7

This study analyzes that compatibility and interoperability issues related to the use of the USAF NAVSTAR Global Positioning System for civil aviation purposes. It also compares the USSR GLONASS navigation system to GPS to provide similar services worldwide. The GPS is primarily a military asset with significant civil applications especially as it applies to air traffic control (ATC). It is recognized by the civil sector as a system which will revolutionize the present day navigation methodology and indeed make way for new ATC concepts and procedures. Several compatibility and interoperability issues are described wherein the system integrity issue remains outstanding and must be resolved prior to using GPS for civil aviation. It appears the USAF and FAA intend to utilize GPS to meet their air navigation system requirements of the future. However, the USAF GPS program implementation is years ahead of the FAA. It is recommended the programs be compared and evaluated to ensure maximum compatibility and to expedite the use of GPS for civil applications. FAA is presently working with the USSR and the International Civil Aviation Organization (ICAO) in an effort to develop international standards for satellite-based navigation systems such as GPS and GLONASS. This effort appears to be progressing well in spite of limited data regarding the GLONASS system. GRA

05

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A90-27975
CREDITABLE COMMUTER
ALAN POSTLETHWAITE Flight International (ISSN 0015-3710), vol. 137, Feb. 28-Mar. 6, 1990, p. 24-30.
Copyright

An account is given of the design features, performance capabilities, and prospects for commercial operation in Western commuter markets of the Czechoslovak L-610 40-seat airliner. Attention is given to the comparative levels of passenger comfort and convenience incorporated in the design, as well as to the degree of technological sophistication revealed by the M602 three-shaft turboprop engine used by the two-engine aircraft. The airframe primary structure is of conventional, machined and chemically milled Al alloy panel construction employing flush rivets, spot welds, or adhesive joints in assembly. Aeroflot is scheduled to purchase 130 L-610s over the course of five years. O.C.

A90-27993*# Purdue Univ., West Lafayette, IN.
MULTIOBJECTIVE DECISION MAKING IN A FUZZY ENVIRONMENT WITH APPLICATIONS TO HELICOPTER DESIGN
A. K. DHINGRA, S. S. RAO (Purdue University, West Lafayette, IN), and H. MIURA (NASA, Ames Research Center, Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 28, April 1990, p. 703-710. Previously cited in issue 22, p. 3648, Accession no.

A88-51946. refs
(Contract NCA2-223)

A90-28152
DESIGN, EVALUATION AND PROOF-OF-CONCEPT FLIGHTS OF A MAIN ROTOR INTERBLADE VISCOELASTIC DAMPING SYSTEM
BRUNO GUIMBAL (Aerospatiale, Division Helicopteres, Marignane, France) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 3-15.
Copyright
The design, analytical modeling, and analysis of an interblade damping system for a hinged helicopter rotor hub are presented. The validation of the concept by a flight on a modified Dauphin helicopter is reported. The test program included drive strain stability evaluation with and without changes in engine governors, ground and air resonance testing, and flight at high speed and high g's over the standard Dauphin envelope. Potential applications for main and tail rotors are discussed, and the concept's application to the current development of the compact, composite 'Spheriflex' main rotor hub is addressed. C.D.

A90-28153
HELICOPTER GROUND/AIR RESONANCE INCLUDING ROTOR SHAFT FLEXIBILITY AND CONTROL COUPLING
ROBERT G. LOEWY and MARK ZOTTO (Rensselaer Polytechnic Institute, Troy, NY) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 19-32. refs
(Contract DAAG29-82-K-0093)
Copyright
The effects of rotor shaft flexibility and the associated rotor control coupling on the so-called ground/air resonance instability of helicopters are investigated. Linearized equations of motion are derived for a mathematical model with a rigid airframe, a rotor shaft flexible between the swash plate and hub, and a fully articulated rotor with rigid blades. The equations are presented in a form which emphasizes the differences between hub motions resulting from fuselage motion and those due to shaft flexibility. C.D.

A90-28154
EXAMINATION OF DYNAMIC CHARACTERISTICS OF UH-60A AND EH-60A AIRFRAME STRUCTURES
JASON A. DURNO and ROBERT K. GOODMAN (Sikorsky Aircraft, Stratford, CT) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 33-50. refs
Copyright
Recent advances in modal testing technology have provided a wealth of information on the vibration characteristics of two Sikorsky helicopter airframes: the UH-60A and a close derivative, the EH-60A. This information is used to create an understanding of the vibration of the H-60 in flight and the extent to which the derivative differs, and provide insight into what modifications to airframe design will benefit future derivatives of the H-60. Natural frequencies and mode shapes obtained from free vibration testing provide the foundation of the investigation. Forced vibration at the rotor driving frequencies is then examined which provides an understanding of the importance of various natural modes. The effects of added equipment, such as Hover Infrared Suppressors and an air conditioner, fuel loading and fixed-system absorbers are then examined. The results indicate that while the structural differences between the airframes were minimal, the vibration characteristics can be significantly different. Innovative absorber designs and locations provide needed modification of dynamic characteristics to reduce 4/rev vibration. Author

A90-28155
A REVIEW OF THE V-22 DYNAMICS VALIDATION PROGRAM
JOHN E. BRUNKEN, DAVID A. POPELKA, and ROBERT J. BRYSON (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 51-64. refs
Copyright
The dynamics validation program for the V-22 is presented relative to the full scale design development and flight test program. Test results are discussed and compared to analytical predictions. Integration of test results into the aircraft development process is also described. The dynamics testing encompasses a broad range of V-22 program elements including the drivetrain, control system, airframe, and rotor. Objectives and results are described for full scale component stiffness, mass, and vibration tests, a series of small scale aeroelastic model tests, drive system critical speed tests, and ground vibration tests of the rotor and airframe. Author

A90-28166
THE EFFECTS OF AERIAL COMBAT ON HELICOPTER STRUCTURAL INTEGRITY
CARL G. SCHAEFER, JR. (U.S. Navy, Naval Air Systems Command, Washington, DC) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 197-210. refs
Copyright
Within the last decade, several U.S. Navy, Marine Corps, and Army flight load surveys have demonstrated that air combat can have adverse effects on the static and fatigue capabilities of helicopter dynamic components, stationary controls, and airframe structures. Although these air combat flight load surveys were flown within the confines of the existing helicopter flight envelopes, substantially elevated component loads over those determined during contractor flight stress surveys and structural demonstrations were found. Component loads were found to be sensitive to a number of air combat variables including pilot technique, adversary type, control sensitivity, and aircraft response. Author

A90-28167* Army Aviation Systems Command, Moffett Field, CA.
HARP MODEL ROTOR TEST AT THE DNW
SETH DAWSON (U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA), DAVID JORDAN, CHARLES SMITH (NASA, Ames Research Center, Moffett Field, CA), JAMES EKINS, LOU SILVERTHORN (McDonnell Douglas Helicopter Co., Mesa, AZ) et al. IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 211-227. refs
Copyright
Data from a test of a dynamically scaled model of the Hughes Advanced Rotor Program (HARP) bearingless model main rotor and 369K tail rotor are reported. The history of the HARP program and its goals are reviewed, and the main and tail rotor models are described. The test facilities and instrumentation are described, and wind tunnel test data are presented on hover, forward flight performance, and blade-vortex interaction. Performance data, acoustic data, and dynamic data from near field/far field and shear layer studies are presented. C.D.

A90-28170
THE POINTER - TEST AND EVALUATION OF THE TILTROTOR UAV
ROBERT D. MCCLURE and PATRICK G. HALL (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 243-250.
Copyright
The Pointer is a small, unmanned serial vehicle (UAV) developed by the Bell-Boeing tiltrotor team to demonstrate the advantages of tiltrotor technology in a UAV application. The first concept demonstrator vehicle has been assembled. Ground tests and wind tunnel tests have been conducted, and flight testing has begun. This paper discusses the Pointer's test program to date and future planned activities to complete developmental flight testing. It also

discusses the unique requirements imposed on the tiltrotor UAV test pilot, and concludes with some lessons learned about UAV testing in general. Author

A90-28173

A COMPREHENSIVE HOVER TEST OF THE AIRLOADS AND AIRFLOW OF AN EXTENSIVELY INSTRUMENTED MODEL HELICOPTER ROTOR

PETER F. LORBER, R. CHARLES STAUTER, and ANTON J. LANDGREBE (United Technologies Research Center, East Hartford, CT) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 281-295. refs
(Contract DAAK51-83-C-0045)
Copyright

A model rotor test has been performed on the UH-60A main rotor in order to obtain a comprehensive set of data for investigating the aerodynamics of a hovering model rotor and for validation of computational prediction methods. A systematic and consistent set of rotor performance data, blade surface pressures, blade spanwise airload distributions, blade surface conditions, flow field velocities, wake geometry data, and aeroelastic deflections are reported. The model was tested using two interchangeable tips: a swept tip that corresponds to the basic rotor and a 3:1 tapered tip, and the results obtained with the two tips are compared. C.D.

A90-28175* Continuum Dynamics, Inc., Princeton, NJ.

OPTIMIZATION OF ROTOR PERFORMANCE IN HOVER AND AXIAL FLIGHT USING A FREE WAKE ANALYSIS

T. R. QUACKENBUSH, A. E. KAUFMAN, D. A. WACHSPRESS (Continuum Dynamics, Inc., Princeton, NJ), and D. B. BLISS (Duke University, Durham, NC) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 311-321. refs
(Contract NAS2-12789)
Copyright

Performance optimization for rotors in hover and axial flight is a topic of continuing importance to rotorcraft designers. The aim of this effort was to demonstrate that a numerical performance optimization algorithm could be coupled to an existing free wake hover code. This code, dubbed EHPIC (Evaluation of Hover Performacne using Influence Coefficients), uses a quasi-linear wake relaxation to solve for the rotor performance. The coupling was accomplished by expanding of the matrix of linearized influence coefficients in EHPIC to accommodate design variables and by deriving new coefficients for linearized equations governing perturbations in power and thrust. These coefficients formed the input to a linear optimization analysis, which used the flow tangency conditions on the blade and in the wake to impose equality constraints on the expanded system of equations; user-specified inequality constraints were also employed to bound the changes in the design. It was found that this locally linearized analysis could be invoked to predict a design change that would produce a reduction in the power required by the rotor at constant thrust. Thus, an efficient search for improved versions of the baseline design can be carried out while retaining the accuracy inherent in a free wake/lifting surface performance analysis. A variety of sample problems were undertaken to demonstrate the success of this approach in reducing the power required at a specified thrust for several representative rotor configurations in hover and axial flight. Author

A90-28188

NEW CONCEPT FOR IMPROVED NONMETALLIC EROSION PROTECTION SYSTEMS

D. A. HAYNIE (Bell Helicopter Textron, Inc., Fort Worth, TX), K. M. KALUMUCK, and G. L. CHAHINE IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 463-475. Research supported by the U.S. Army. refs
Copyright

A new multilayer, nonmetallic erosion protection system for helicopter blade leading edges has resulted in a longer wear life and a more gradual failure mode in rain. A brief description of the operating and environmental conditions considered in the study is presented. Flow field and particle trajectory programs are used to determine particle and impact velocity, angle, and location as a function of particle size and blade geometry, velocity, and angle-of-attack. Stress and strain histories are predicted by a one-dimensional elastic and plastic stress wave propagation model that employs dynamic stress-strain curves obtained using a split Hopkinson pressure bar. Whirling arm erosion tests indicate the multilayer EPS has not only a more benign failure mode, but a wear life 138 percent longer, on average, than that of the single-layer EPS. Author

A90-28196*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

TIP VORTEX GEOMETRY OF A HOVERING HELICOPTER ROTOR IN GROUND EFFECT

JEFFREY S. LIGHT (NASA, Ames Research Center, Moffett Field, CA) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 551-562. refs

The wide-field shadowgraph method has been used to photograph the tip vortices of a hovering helicopter rotor in ground effect. The shadowgraphs were used to obtain quantitative measurements of the rotor tip vortex geometry both in and out of ground effect. Many important phenomena are visible in the rotor wake using this method. These include the variation in descent and contraction rates of the tip vortices in ground effect, and the interaction between tip vortices in the far wake. The tip vortex geometry from the shadowgraphs is compared with the tip vortex geometry predicted using a free wake hover performance analysis. The free wake analysis accurately predicts the tip vortex geometry both in and out of ground effect. Performance data from the test is compared with the performance predicted using several methods, including the free wake analysis. All methods provided reasonable predictions for the helicopter performance in ground effect. Author

A90-28203

HELICOPTER SIMULATION DEVELOPMENT BY CORRELATION WITH FREQUENCY SWEEP FLIGHT TEST DATA

THADDEUS T. KAPLITA, JOSEPH T. DRISCOLL, MYRON A. DIFTLER, and STEVEN W. HONG (Sikorsky Aircraft, West Palm Beach, FL) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 681-692. refs
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The preliminary results of a nonlinear general helicopter simulation (GENHEL) development effort for the CH-53E helicopter using data from an extensive helicopter frequency sweep flight test program are described. Current frequency domain correlation results are presented for forward flight, with and without external load. The simulation and flight test time histories are converted into frequency-response Bode plots by spectral analysis techniques. System eigenvalues are examined for various flight conditions. The frequency response of the helicopter is analyzed in terms of the poles and zeroes of the linear system and major modes are identified across the frequency range. The rotor dynamics, and particularly the blade regressive mode, are shown to be important for simulation fidelity. C.D.

A90-28211

EH101 DESIGN AND DEVELOPMENT STATUS

RICHARD I. CASE (Westland Helicopters, Ltd., Yeovil, England) and FILIPPO REINA (Costruzioni Aeronautiche Giovanni Agusta S.p.A., Cascina Costa, Italy) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 793-801.
Copyright

The British and Italian governments are jointly developing the next generation of ASW helicopter, the EH101. This paper discusses the optimization being conducted to satisfy both operational desires and qualification requirements. The design criteria selected to achieve a successful integrated program are summarized, and some of the design tradeoffs necessary to reconcile conflicting requirements are discussed. The joint program is outlined and a status report on progress to date is provided. C.D.

A90-28212
HELICOPTER DESIGN OPTIMIZATION FOR MANEUVERABILITY AND AGILITY
JOHN R. OLSON and MARK W. SCOTT (Sikorsky Aircraft, Stratford, CT) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 803-814.
Copyright
The results are reported of a study whose objective is to establish maneuverability design guidelines for helicopters. The maneuvers studied include hover bob-up, acceleration , deceleration, climb, turns, and high-speed pullup. Installed power, blade loading, and blade lock number are the most weight-efficient design variables for improving overall maneuverability. Disk loading and tip speed strongly influence individual maneuvers, but are less attractive design optimizers because they affect different maneuvers in opposite directions. C.D.

A90-28213
THE NEW SPHERIFLEX TAIL ROTOR FOR THE SUPER PUMA MARK 2
BRUNO GUIMBAL and JEAN-LUC LEMAN (Aerospatiale, Division Helicopteres, Marignane, France) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 829-836.
Copyright
Technical aspects involved in the development of the new Super Puma Mk II helicopter tail rotor are addressed. The main and subsidiary concepts of the design are reviewed, and preliminary tests of the elastomeric parts and blade structure are described along with proof-of-concept whirling tests. Dynamic analysis of the couplings, in-plane rigidity, and loads are considered, and the development status is shown. C.D.

A90-28214
THE FOUR-BLADED MAIN ROTOR SYSTEM FOR THE AH-1W HELICOPTER
JAMES H. HARSE (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 837-850.
Copyright
A new four-bladed main rotor system based on bearingless rotor technology has been designed and fabricated and is currently undergoing flight testing on a modified AH-1W attack helicopter. Other systems also being incorporated under this program include a Liquid Inertia Vibration Eliminator (LIVE) pylon suspension system, an uprated main rotor transmission, and a digital automatic flight control system. This paper describes these advanced systems, and the results of the preflight component and system testing are presented. The accomplishments of the flight test program to date are discussed and the potential benefits of these systems to the AH-1W helicopter are shown. C.D.

A90-28215
A COMPARISON OF FOUR VERSUS FIVE BLADES FOR THE MAIN ROTOR OF A LIGHT HELICOPTER
KENNETH B. AMER (Rand Corp., Santa Monica, CA) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 851-857. refs
Copyright
The use of four-bladed and five-bladed main rotors in a light helicopter is comparatively studied. It is shown that there are major advantages for the five-bladed rotor in terms of reduced vibration levels. Weight data correlations show advantages for the five-bladed rotor in the areas of blade weight, hub weight, controls weight, and flight controls hydraulic weight. The four-bladed design has some advantage in vulnerabilty to explosive rounds, while the two designs are about equal with regard to structural design and maintenance. Both designs result in reasonable values of blade aspect ratio for a light helicopter. C.D.

A90-28223
V-22 BALLISTIC VULNERABILITY HARDENING PROGRAM
DARRELL L. LIARDON, JACK R. JOHNSON (Bell Helicopter Textron, Inc., Fort Worth, TX), and JOHN HOLTROP (U.S. Navy, Naval Weapons Center, China Lake, CA) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 927-937. refs
Copyright
An effective ballistic vulnerability hardening program for the V-22 Osprey aircraft has been developed and is currently being administered by the Bell/Boeing Tiltrotor Team in conjunction with Naval Air Systems Command and Naval Weapons Center. The ballistic hardening program includes systematic requirements development, extensive analysis and testing, and development of ballistic tolerant design features. The program is being administered through all phases of V-22 aircraft development, including Preliminary Design and Full Scale Development, and will be continued in Pilot Production. Due to extensive use of composite materials and the V-22's unique tiltrotor design, ballistics testing played a critical role in supporting the analysis used for the vulnerability assessment. The testing and analysis enabled the implementation of design decisions which resulted in a design that meets all ballistic vulnerability requirements. As a result, the V-22 Osprey will be the most survivable medium-lift-rotorcraft in the western world. Author

A90-28226
ROTOR LOADS VALIDATION UTILIZING A COUPLED AEROELASTIC ANALYSIS WITH REFINED AERODYNAMIC MODELING
MICHAEL S. TOROK and INDERJIT CHOPRA (Maryland, University, College Park) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 973-987. refs
(Contract DAAL03-88-C-0002)
Copyright
The effects of refined aerodynamic modeling on rotor blade section loads and bending moments are investigated. A nonlinear aerodynamic analysis, for attached flow, separated flow, and dynamic stall, is incorporated into a coupled rotor aeroelastic analysis. Both prescribed and free wake models are also coupled into the analysis. Blade responses and loads are calculated using a finite element formulation in space and time. A modified Newton iterative method is used to calculate blade response and trim controls as one coupled solution. A correlation with SA349/2 Aerospatiale Gazelle flight test data is used to validate the analysis. Trim controls, blade-section aerodynamic loads, and blade-flap bending moments are satisfactory predicted. Author

A90-28229
PERIODIC RESPONSE OF THIN-WALLED COMPOSITE BLADES
O. RAND (Technion - Israel Institute of Technology, Haifa) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 1017-1029. refs
Copyright
Theoretical investigation of the periodic response of thin-walled composite helicopter blades operating under combined transverse, torsional and centrifugal loads, is presented. The structural analysis is derived for slender blades and includes the classical degrees of freedom in addition to a detailed description of the warping displacements. Thus, using a relatively small number of unknowns, the present formulation enables complete representation of both torsional- and bending-related shear stresses, resultant shear loads

and torsional moment. Consequently, all the composite-associated coupling effects are consistently modeled. The influence of the coupling effects on the blade periodic response and stress distributions in forward flight, is explored as a function of the involved elastic moduli distributions over the cross-sectional walls. Author

A90-28230
RELATIVE AEROMECHANICAL STABILITY CHARACTERISTICS FOR HINGELESS AND BEARINGLESS ROTORS
WILLIAM H. WELLER (United Technologies Research Center, East Hartford, CT) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 1031-1044. refs
Copyright

The aeromechanical stability characteristics of two soft-inplane main rotor models operating in hover condition are compared. One model is a bearingless rotor configuration with a flexure connecting the blade to the hub center, a torsionally-stiff cuff, and a shear-restraining damper mechanism that attaches the inboard end of the cuff to the flexure. The shear restraint includes an elastomeric damper for edgewise damping. The second model is that of a hingeless rotor designed with a flexure connecting the blade to the inboard pitch bearing. The hingeless rotor model does not have any auxiliary damping source. The results indicate that the hingeless rotor concept offers better air-resonance stability margins due to its aeroelastic characteristics. For ground resonance, however, the bearingless rotor is better because of the larger structural damping arising from its shear-restraint damper. C.D.

A90-28232
STRIKE TOLERANT MAIN ROTOR BLADE TIP
PAUL F. MALONEY, DOUG E. DALEY (Kaman Aerospace Corp., Bloomfield, CT), and LEROY T. BURROWS (U.S. Army, Aviation Systems Command, Fort Eustis, VA) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 1055-1063.
Copyright

This paper briefly documents the results of a survey of main rotor blade obstacle strikes that resulted in damage-causing mishaps and describes in detail a program for the design, fabrication, static test, and full-scale whirl testing of a strike-tolerant replaceable main rotor blade tip design concept for increasing helicopter survivability. The concept found to be best is a frangible tip configuration designed to withstand ultimate flight loads. Fault lines are intentionally designed into the tip structure so that failure would occur in these areas upon impact. C.D.

A90-28233
MODELING STRATEGIES FOR CRASHWORTHINESS ANALYSIS OF LANDING GEARS
A. BOLUKBASI and J. SEN (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 1065-1073. refs
(Contract DAAJ02-85-C-0049)
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This paper presents modeling strategies and procedures for crashworthiness analysis of landing gears using program KRASH. Landing gear modeling capabilities and limitations of program KRASH, techniques to avoid numerical problems and the required program modifications, and further enhancements are outlined. The results of crashworthiness analysis developed by MDHC are presented and compared with test results. The KRASH models discussed include a detailed model of a utility helicopter, a model of the dynamic test fixture (iron-bird) that simulated the utility helicopter in tests and models of individual gears. Comparison of the dynamic test results and KRASH analysis results showed good correlation. The successful use of program KRASH for landing gear crashworthiness analysis to a great extent depends on a good understanding of the capabilities and limitations of the program and the sequence of events occurring during crash-impact. Author

A90-28235
EFFECTS OF DAMAGE ON POST-BUCKLED SKIN-STIFFENER COMPOSITE SKIN PANELS
NAM D. PHAN and WILLIAM J. KESACK (Boeing Helicopters, Philadelphia, PA) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 1083-1090. refs
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Experimental investigations were conducted to study the effects of visible impact damage on the strength of the V-22 composite skin-stiffner skin panels. Over 40 24-inch by 24-inch picture frame specimens with different thicknesses were fabricated and tested statically and in fatigue under various environment conditions. A significant reduction in panel strength was observed as a result of impact damage. The data showed that fatigue loading and exposure to adverse environmental conditions did not affect the failure loads. The V-22 composite skins have demonstrated a high degree of damage tolerance and fatigue resistance. Author

A90-28236
UNIQUE METHODOLOGY USED IN THE BELL-BOEING V-22 MAIN LANDING GEAR LANDING LOADS ANALYSIS AND DROP TESTS
BARBARA MCCOWN-MCCLINTICK (Boeing Helicopters, Philadelphia, PA) and RALPH DARLINGTON (Dowty Canada, Ltd., Ajax) AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Paper. 9 p.
Copyright

During the loads prediction phase of the V-22 main landing gear, it was found that unique design features of the V-22 favorably influenced the landing loads. During landings, the aircraft structural flexibility is dominated by the symmetric wing bending mode. The rotor and engine nacelle mass at each end of the wing accentuates the effect, resulting in significant loads reduction when the aircraft flexibility is included in landing loads analyses. In order to take full advantage of the loads reduction, the drop test rig was modified from a two mass system to a three mass system. The three mass system simulated one aircraft rigid body mode and one flexible mode. The dynamic elements of the landing gear were designed using the three mass system. Drop tests were performed and correlated well with the load predictions. Author

A90-28238* Cornell Univ., Ithaca, NY.
TILT ROTOR AIRCRAFT AEROACOUSTICS
ALBERT R. GEORGE (Cornell University, Ithaca, NY), CHARLES A. SMITH (NASA, Aerodynamics Div., Washington, DC), MARTIN D. MAISEL (NASA, Ames Research Center; U.S. Army, Research and Technology Activity, Moffett Field, CA), and JOHN T. BRIEGER (Bell Helicopter Textron, Inc., Fort Worth, TX) AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Paper. 21 p. Research supported by the National Research Council. refs
(Contract NAG2-554)
Copyright

This paper studies the state of knowledge and the needed improvement in noise methodology and measurements for tilt rotor aircraft. Similarities and differences between tilt rotor aeroacoustic conditions and helicopter and propeller experience are identified. A discussion of the possible principal noise mechanisms throughout the flight envelope shows a need for further experimental and analytical investigations to develop an adequate understanding of the important sources and influencing factors. Existing experimental data from flight tests suggest terminal area noise reduction by operating within certain portions of the conversion flight envelope. Prediction methods are found to provide approximate indications only for low frequency harmonic and broadband noise for several of the tilt rotor's operating conditions. The acoustic effects of the hover case 'fountain' flow are pronounced and need further research. Impulsive noise and high frequency harmonic noise

remain problems, as on helicopters, pending major improvements in wake, unsteady aerodynamics, and acoustics methodology.
Author

A90-28239
V-22 AERODYNAMIC LOADS ANALYSIS AND DEVELOPMENT OF LOADS ALLEVIATION FLIGHT CONTROL SYSTEM
ASHOK AGNIHOTRI, WARREN SCHUESSLER, JR., and ROGER MARR (Bell Helicopter Textron, Inc., Fort Worth, TX) AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Paper. 8 p.
Copyright
The paper presents the new standards of structural design requirements necessary for the V-22 tiltrotor aircraft. The requirements are significantly more severe in strength and fatigue than the current design practice. Structural design loads were accomplished through significant automation of the load analyses and data basing and in order to meet strength and fatigue requirements, a loads alleviation flight control system (LAFCS) was developed. This system helped maintain empty weight to a minimum and improved handling quality in most cases. It is concluded that final modifications may be made during flight, to optimize the LAFCS. R.E.P.

A90-28240* Boeing Helicopter Co., Philadelphia, PA.
THE PREDICTION OF LOADS ON THE BOEING HELICOPTERS MODEL 360 ROTOR
LEO DADONE, DAVID POLING (Boeing Helicopters, Philadelphia, PA), FRANK CARADONNA, MARK SILVA (NASA, Ames Research Center;, U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA), and K. RAMACHANDRAN (Flow Analysis, Inc., Mountain View, CA) AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Paper. 15 p. refs
Copyright
Results are presented from a test/theory correlation investigation involving three rotor-analysis codes, two full potential rotor flow CFD solvers, and data obtained from tests on the Model 360 helicopter's rotor. Attention is given to the problem of reliable higher harmonic loading prediction. It is found that the rotor hover performance and loading experimental data are in excellent agreement with a novel, full potential free-wake computational technology; the need for a multiple tip-vortex wake model's use in predicting vibratory airloads is confirmed. O.C.

A90-28244
TILTROTOR AEROSERVOELASTIC DESIGN METHODOLOGY AT BHTI
THOMAS C. PARHAM, JR., DERCHANG CHAO, and PETER ZWILLENBERG (Bell Helicopter Textron, Inc., Fort Worth, TX) AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Paper. 11 p. refs
Copyright
The design of tiltrotor aircraft must consider both proprotor/pylon stability as well as conventional fixed surface and control surface flutter. Both types of stability characteristics can be affected by the aircraft flight control system (FCS), and thus the aeroservoelastic stability must be considered during the development of the FCS. This paper presents the methodology developed at Bell Helicopter Testron Inc. (BHTI) for aeroservoelastic analysis to support the design of tiltrotor aircraft in high speed airplane mode. This methodology includes the use of a BHTI-developed computer code for the analysis of proprotor/pylon stability including the effects of the FCS and MSC/NASTRAN with the aeroelastic module for the analysis of fixed surface and control surface aeroservoelastic stability.
Author

A90-28993
A STUDY OF THE STRENGTH CHARACTERISTICS OF A TWIN-FUSELAGE AIRCRAFT WITH A TRAPEZOID WING SYSTEM [ISSLEDOVANIE PROCHNOSTNYKH KHARAKTERISTIK DVUKHFIUZELIAZHNOGO SAMOLETA S ZAMKNUTOI SISTEMOI KRYL'EV]
V. N. SEMENOV TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 1, 1989, p. 120-125. In Russian. refs
Copyright
The advantages of a twin-fuselage aircraft scheme with a trapezoid wing system are examined in terms of the weight coefficient and stiffness. A comparison of the strength characteristics is made with reference to data for a 250-passenger twin-fuselage aircraft with a take-off mass of about 112 tons. It is shown, in particular, that the use of a trapezoid wing with a twin-fuselage scheme provides an additional 20-27-percent weight reduction of the wing system, with an almost a factor of 5 reduction in the maximum wing deflection. V.L.

A90-29188
EFFICIENCY OF USING A MULTIPLE-WALL TORSION BOX IN THE LOAD-BEARING STRUCTURES OF LIFTING SURFACES [OB EFFEKTIVNOSTI PRIMENENIIA MNOGOSTENOCHNOGO KESSONA V KONSTRUKTIVNO-SILOVOI SKHEME NESUSHCHEI POVERKHNOSTI]
E. K. LIPIN, V. E. TENIAEVA, and V. M. FROLOV TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 3, 1989, p. 61-71. In Russian.
Copyright
The stiffness and mass characteristics of the multiple-wall and multiple-rib versions of the torsion box of the central lifting surface of aircraft were studied for the case of concentrated and distributed loading. The advantages of using a multiple-wall torsion box, rather than the multiple-rib box, for highly loaded lifting surface are demonstrated. V.L.

A90-29191
THE USE OF AUTOMATED PARAMETRIC ANALYSIS FOR SELECTING EFFICIENT STRUCTURAL SCHEMES FOR WINGS [PRIMENENIE AVTOMATIZIROVANNOGO PARAMETRICHESKOGO ANALIZA DLIA VYBORA RATSIONAL'NYKH KONSTRUKTIVNO-SILOVYKH SKHEM KRYLA]
A. K. KOVALEVSKII and E. K. LIPIN TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 3, 1989, p. 91-100. In Russian. refs
Copyright
A method and a set of parametric analysis software have been developed for selecting efficient wing structures with allowance for strength and stability constraints. Stress-strain analysis is carried out by the finite element method. As an example, structural optimization of a low-aspect-ratio wing is conducted for three loading cases. It is shown that the lowest mass is obtained with a multiple-spar wing. V.L.

A90-29237*# Maryland Univ., College Park.
AEROELASTIC OPTIMIZATION OF A HELICOPTER ROTOR USING AN EFFICIENT SENSITIVITY ANALYSIS
JOON W. LIM and INDERJIT CHOPRA (Maryland, University, College Park) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 82-96. refs
(Contract NAG1-739)
(AIAA PAPER 90-0951) Copyright
To reduce oscillatory hub loads in forward flight, a structural optimization analysis of a hingeless helicopter rotor has been developed and applied. The aeroelastic analysis of the rotor is based on a finite element method in space and time, and linked with automated optimization algorithms. For the optimization analysis two types of structural representation are used: a generic stiffness-distribution and a single-cell thin-walled beam. For the first type, the design variables are nonstructural mass and its placement, chordwise center of gravity offset from the elastic axis, and stiffness. For the second type, width, height and thickness of spar are used as design variables. For the behavior constraints, frequency placement, autorotational inertia and aeroelastic stability of the blade are included. The required sensitivity derivatives are

obtained using a direct analytical approach. An optimum oscillatory hub load shows a 25-77 percent reduction for the generic blade, and 30-50 percent reduction for the box-beam. N.B.

A90-29238#

EXPLORATORY DESIGN STUDIES USING AN INTEGRATED MULTIDISCIPLINARY SYNTHESIS CAPABILITY FOR ACTIVELY CONTROLLED COMPOSITE WINGS

E. LIVNE, L. A. SCHMIT, and P. P. FRIEDMANN (California, University, Los Angeles) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 97-109. refs
(Contract F49620-87-K-0003)
(AIAA PAPER 90-0953) Copyright

Analysis and synthesis techniques used in a newly developed multidisciplinary control augmented fiber composite wing optimization capability are reviewed. Structural, aerodynamic and control system mathematical models that are suitable for the preliminary design of real airplanes are used in an integrated manner to synthesize improved designs of wings and their active control systems. Optimization techniques developed for structural synthesis are adapted to the integrated multidisciplinary wing synthesis problem, in which constraints from several disciplines are taken into account simultaneously and the design space is opened up to include structural, control system and aerodynamic design variables. The effectiveness and efficiency of the new capability are studied using a mathematical model of a remotely piloted vehicle (RPV). Author

A90-29239#

INFLUENCE OF STRUCTURAL AND AERODYNAMIC MODELING ON FLUTTER ANALYSIS

ALFRED G. STRIZ (Oklahoma, University, Norman) and VIPPERLA B. VENKAYYA (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 110-118. refs
(AIAA PAPER 90-0954)

The dynamic aeroelastic capabilities in the ASTROS automated structural optimization system were used to evaluate the flutter behavior of various fully built-up element wing models in subsonic and supersonic flow. The flutter module performance was tested against results from other codes (MSC/NASTRAN and FASTEX). Fully built-up finite element models with different variables were investigated for the influence of the free vibration and flutter characteristics of various modeling factors: number of selected modes, solution procedures, aerodynamic panel size and placement, etc. Most of the results presented address the influence of structural and aerodymanic modeling on flutter and normal modes analysis. However, some preliminary results have been obtained on how various parameters and modeling errors affect the final minimum weight design in optimization. N.B.

A90-29240#

EVALUATION OF CURRENT MULTIOBJECTIVE OPTIMIZATION METHODS FOR AERODYNAMIC PROBLEMS USING CFD CODES

H. IDE, M. LEVINE, and D. OMINSKY (Rockwell International Corp., Los Angeles, CA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 119-126. Research supported by the Rockwell International Independent Research and Development Program. refs
(AIAA PAPER 90-0955) Copyright

Two types of multiobjective optimization solution methods are considered: the first type involves several separate local optimizations and a global one to link them together; the second type represents all subsystems and global objectives included in a single objective function (or composite functions). Two simple optimization techniques, one of each type, are selected and investigated for identification of their characteristics, using a wing wind tunnel model configuration. Both methods performed similarly for the sample problem. The results show that the second technique reduces optimization time if the initial condition is well established. If the problem is highly nonlinear, the first technique can identify nonlinearities between local optimizations, even if they are linear. Therefore, it is recommended to investigate the use of both types as a hybrid method for complicated configurations. Results are presented for rigid configurations at Mach number 0.9 and zero angle of attack. N.B.

A90-29305*# Virginia Univ., Charlottesville.

THERMAL STRUCTURES - FOUR DECADES OF PROGRESS

EARL A. THORNTON (Virginia, University, Charlottesville) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 794-814. Research supported by NASA. refs
(AIAA PAPER 90-0971) Copyright

Since the first supersonic flight in October 1947, the United States has designed, developed and flown flight vehicles within increasingly severe aerothermal environments. Over this period, major advances in engineering capabilities have occurred that will enable the design of thermal structures for high speed flight vehicles in the twenty-first century. This paper surveys progress in thermal-structures for the last four decades to provide a historical perspective for future efforts. Author

A90-29381*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

AEROSERVOELASTICITY

THOMAS E. NOLL (NASA, Langley Research Center, Hampton, VA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1560-1570. refs
(AIAA PAPER 90-1073) Copyright

The paper describes recent accomplishments and current research projects along four main thrusts in aeroservoelasticity at NASA Langley. One activity focuses on enhancing the modeling and analysis procedures to accurately predict aeroservoelastic interactions. Improvements to the minimum-state method of approximating unsteady aerodynamics are shown to provide precise low-order models for design and simulation tasks. Recent extensions in aerodynamic correction-factor methodology are also described. With respect to analysis procedures, the paper reviews novel enhancements to matched filter theory and random process theory for predicting the critical gust profile and the associated time-correlated gust loads for structural design considerations. Two research projects leading towards improved design capability are also summarized: (1) an integrated structure/control design capability and (2) procedures for obtaining low-order robust digital control laws for aeroelastic applications. Author

A90-29384#

PIEZOELECTRIC ACTUATORS FOR HELICOPTER ROTOR CONTROL

STEVEN R. HALL (MIT, Cambridge, MA) and RONALD L. SPANGLER, JR. IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1589-1599. refs
(AIAA PAPER 90-1076) Copyright

The feasibility of piezoelectric materials as integrated actuators for a trailing edge helicopter blade flap is demonstrated. A model of the dynamic behavior of this actuator is developed for the case of a fixed airfoil section using an aeroelastic Rayleigh-Ritz procedure. From this model a set of scaling laws for dynamic

similarity between scaled test articles and representative full scale blades is developed. The design of a wind tunnel experimental model used to verify actuator feasibility and effectiveness is presented, as are results of wind tunnel testing, including the amplitude response of the flap angle to the applied electric field, as well as the lift and moment on the airfoil due to the flap deflection. The ramifications of scaling and the representative full scale performance indicated by the results are discussed.
Author

A90-29386*# Purdue Univ., West Lafayette, IN.
STATIC AEROELASTIC BEHAVIOR OF AN ADAPTIVE LAMINATED PIEZOELECTRIC COMPOSITE WING
T. A. WEISSHAAR (Purdue University, West Lafayette, IN) and S. M. EHLERS IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1611-1623. refs
(Contract NSG-1157)
(AIAA PAPER 90-1078) Copyright

The effect of using an adaptive material to modify the static aeroelastic behavior of a uniform wing is examined. The wing structure is idealized as a laminated sandwich structure with piezoelectric layers in the upper and lower skins. A feedback system that senses the wing root loads applies a constant electric field to the piezoelectric actuator. Modification of pure torsional deformaton behavior and pure bending deformation are investigated, as is the case of an anisotropic composite swept wing. The use of piezoelectric actuators to create an adaptive structure is found to alter static aeroelastic behavior in that the proper choice of the feedback gain can increase or decrease the aeroelastic divergence speed. This concept also may be used to actively change the lift effectiveness of a wing. The ability to modify static aeroelastic behavior is limited by physical limitations of the piezoelectric material and the manner in which it is integrated into the parent structure.
Author

A90-29389#
HINGELESS ROTOR DYNAMICS IN COORDINATED TURNS
ROBERTO CELI (Maryland, University, College Park) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1679-1689. refs
(Contract DAAL03-88-C-002)
(AIAA PAPER 90-1117) Copyright

This paper describes the results of a numerical study of the aeroelastic stability and response of a soft-in-plane, hingeless rotor helicopter undergoing coordinated steady turn. The combined effects of turn rate, aircraft speed, flight path angle, and direction of turn are discussed. The use of analyses valid only for straight flight is examined. The results indicate that steady level turns stabilize the lag modes but may destabilize some flap modes. Descending turns are destabilizing and may limit the maneuver envelope of the helicopter.
Author

A90-29394#
DYNAMIC ANALYSIS OF ROTOR BLADES WITH ROTOR RETENTION DESIGN VARIATIONS
R. G. LOEWY, A. ROSEN, M. B. MATHEW (Rensselaer Polytechnic Institute, Troy, NY), and M. ZOTTO IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1762-1772. refs
(Contract DAAL03-88-C-004)
(AIAA PAPER 90-1159) Copyright

Kinematic and elastic couplings are often provided in rotor-blade root-retention systems to improve aeroelastic or flight stability. The complexity of accurate structural dynamic and aeroelastic rotor analyses, however, makes design analysis of more than just a few such variations seem a heavy computational burden. If the classical Lagrangian multiplier variational method is incorporated in a unified formulation, the generalized coordinate advantages can be preserved, and it will be unnecessary to repeat the structural part of the analysis when root boundary conditions change. This paper postulates two idealized rotor hub-hinge system models; after reviewing the analysis methodology, it is used to examine the in vacuo free vibration characteristics of rotor blades with bulk elastic properties outboard of the attachment point typical of present-generation rotorcraft. Trends of natural frequencies, damping ratios, and the amount of blade pitch induced by root flapping or lagging motions for variations of root retention system parameters are presented.
Author

A90-29395#
AEROELASTIC TAILORING ANALYSIS FOR PRELIMINARY DESIGN OF ADVANCED TURBO PROPELLERS WITH COMPOSITE BLADES
TAKASHI YAMANE (MITI, Mechanical Engineering Laboratory, Tsukuba, Japan) and PERETZ P. FRIEDMANN (California, University, Los Angeles) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1773-1781. refs
Copyright

An analytical study of aeroelastic tailoring has been conducted to determine the flutter characteristics of advanced turbo propellers for preliminary design purposes. The structural dynamic model for composite pretwisted propeller blades developed by Kosmatka and Friedmann (1989) is combined with Smith's (1972) unsteady cascade theory with the sweep corrections and finite span corrections to produce an aeroelastic analysis tool. The free vibration analysis of the SR-3 propeller model built of unidirectional graphite/epoxy, reveals that the natural frequencies of the blade can be changed from baseline values to 53 percent of baseline only by changing fiber orientation. Using p-k modal flutter analysis it was also found that the fiber orientation with a little larger sweep angle than that of the elastic axis can eliminate flutter without any weight penalty and that the corresponding first natural mode has the least bending-torsion coupling. However, the flutter velocity is sensitive to fiber orientation and interblade phase angle. These indicate the effectiveness of the aeroelastic tailoring technique and the convenience of the present analysis technique for the advanced turbo propellers.
Author

A90-29405#
MULTI-OUTPUT IMPLEMENTATION OF A MODIFIED SPARSE TIME DOMAIN TECHNIQUE FOR ROTOR STABILITY TESTING
FREDERICK A. TASKER and INDERJIT CHOPRA (Maryland, University, College Park) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1871-1884. refs
(Contract DAAL03-88-C-002)
(AIAA PAPER 90-0946) Copyright

A modified sparse time domain (STD) technique for studying the stability characteristics of a rotor system is described. The bases of the STD technique of Ibrahim (1987) and Ibrahim time domain method (1977) are discussed. The performance of the technique is evaluated for multioutput and single output implementations. The results are compared with data generated using the standard STD method. It is observed that the modified technique is more accurate in terms of the bias and standard deviation of the damping estimates and faster when the number of modes is less than the order of the data matrix.
I.F.

A90-29467*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
EFFECTS OF HIGHER HARMONIC CONTROL ON ROTOR PERFORMANCE AND CONTROL LOADS
KHANH NGUYEN (NASA, Ames Research Center, Moffett Field, CA) and INDERJIT CHOPRA (Maryland, University, College Park)

AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990. 11 p. refs
(AIAA PAPER 90-1158) Copyright

An analytical study, based on an advanced Higher Harmonic Control (HHC) analysis for helicopter rotor systems, is carried out to investigate HHC application for rotor performance enhancement. The effects of HHC on stall characteristics of rotor and blade pitch-link loads when the system is configured to suppress vibration are also examined. For vibration control, simulated results indicate that HHC may promote early blade stall. Effects of blade torsion frequencies on HHC performance are moderate, and torsionally stiff blades require less actuator power than torsionally soft blades. For rotor performance improvement, a 3 to 5 percent reduction in rotor shaft power can be achieved with 2 deg of two-per-rev blade pitch control. Author

A90-29661
PILOT REPORT - MIG-29
BENJAMIN S. LAMBETH (Rand Corp., Santa Monica, CA) Air Force Magazine (ISSN 0730-6784), vol. 73, April 1990, p. 62-67.
Copyright

A U.S. civilian pilot provides an overall impression of the flight handling characteristics and control and instrumentation contained in the Soviet MiG-29 (Fulcrum) combat/attack aircraft. It is noted that this fighter is a twin-engine aircraft about the size of a U.S. Navy F/A-18 Hornet. Only rear-seat instrumentation (a Soviet pilot flew front seat) was observed; it was generally in the USAF F-105/F-4 vintage design, having a few vertical tape instruments and many round analog dials, and having no radar display, but having a keypad with digital readouts that may have been part of the INS system. A number of standard and aerobatic fighter aircraft maneuvers were flown with apparent good handling characteristics. It is of interest that the attitude reference system has a vertically rotating drum to indicate pitch attitude and a separate aircraft symbol superimposed that rotated through 360 degrees of arc to indicate bank angle. It is pointed out that the flight was more significant for its political than for its aeronautical implications. R.E.P.

A90-29890
THE ALL-COMPOSITE AIRFRAME - DESIGN AND CERTIFICATION
Aerospace Engineering (ISSN 0736-2536), vol. 10, April 1990, p. 17-20.
Copyright

Design, assembly, testing, and certification of the Beech Starship aircraft are discussed. It is noted that assembly of the aircraft is simplified by using sandwich panels with cocured reinforcements for low part count, metal attachment fittings to carry locally high loads, and a wide application of adhesive bonding. During FAA certification, special conditions were applied to various aspects of the airframe. Composite structure was analyzed with damage tolerance methods instead of fatigue life of fail-safe methods, strength after impact damage was regarded as an intrinsic material allowable, identification of environmental effects was considered, and bonded joint failure was evaluated. V.T.

A90-30107* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
A FLIGHT-TEST METHODOLOGY FOR IDENTIFICATION OF AN AERODYNAMIC MODEL FOR A V/STOL AIRCRAFT
R. E. BACH, JR. and B. D. MCNALLY (NASA, Ames Research Center, Moffett Field, CA) IN: Identification and system parameter estimation 1988; IFAC/IFORS Symposium, 8th, Beijing, People's Republic of China, Aug. 27-31, 1988, Selected Papers. Volume 2. Oxford, England and Elmsford, NY, Pergamon Press, 1989, p. 1339-1347. refs
Copyright

This paper describes a flight-test methodology for developing a data base to be used to identify an aerodynamic model of a V/STOL fighter aircraft. The aircraft serves as a test bed at NASA Ames for ongoing research in advanced V/STOL control and display concepts. The flight envelope to be modeled includes hover, transition to conventional flight and back to hover, STOL operation, and normal cruise. Although the aerodynamic model is highly nonlinear, it has been formulated to be linear in the parameters to be identified. Motivation for the flight-test methodology advocated in this paper is based on the choice of a linear least-squares method for model identification. The paper covers elements of the methodology from maneuver design to the completed data base. Major emphasis is placed on the use of state estimation with tracking data to ensure consistency among maneuver variables prior to their entry into the data base. The design and processing of a typical maneuver are illustrated. Author

A90-30117
A STATUS REVIEW OF NON-HELICOPTER V/STOL AIRCRAFT DEVELOPMENT. I
BERNARD LINDENBAUM (Aerial Mobility, Inc., Dayton, OH) Vertiflite (ISSN 0042-4455), vol. 36, Mar.-Apr. 1990, p. 32-43.
Copyright

A brief review of major past V/STOL concepts in the USA and Europe is presented. Attention is first given to the hanging VATOL type as the simplest turbojet/turbofan concept, with the dispersed site fighter Ryan X-13 and the tail sitter C-450 coleopter considered as examples. The turbojet-turbofan powered horizontal attitude take-off and landing (HATOL) concept is then discussed, with the L/C powered Harrier, the C + L type Mirage III V, the L/C + L type Yak-36 and 38, and the U.S./FRG V/STOL tactical fighter considered as examples. Finally, the propeller and prop-rotor V/STOL concept is described, with emphasis on the tilt wing and tilt prop-rotor categories. N.B.

A90-30118
THE VARIABLE-DIAMETER ROTOR - A KEY TO HIGH PERFORMANCE ROTORCRAFT
EVAN A. FRADENBURGH (Sikorsky Aircraft, Stratford, CT) Vertiflite (ISSN 0042-4455), vol. 36, Mar.-Apr. 1990, p. 46-53.
Copyright

For helicopters operating at forward speeds greater than 250 knots, the drag of the large-diameter blades, as well as their aeroelastic behavior and flapping response to gusts, present major obstacles to performance maximization. Attention is presently given to the mechanical and aerodynamic characteristics of variable-diameter helicopter main rotor systems capable of operating in large-diameter mode during hover and low-speed flight, and then reducing diameter to the degree consistent with increasing forward flight. The reliability, safety, and production cost related consequences of such rotor systems are discussed. O.C.

A90-30119
THE COMING AGE OF THE TILTROTOR. II
PHILIP C. NORWINE (Bell Helicopter Textron, Inc., Fort Worth, TX) Vertiflite (ISSN 0042-4455), vol. 36, Mar.-Apr. 1990, p. 54-61.
Copyright

A comprehensive evaluation is made of the commercial prospects and operational advantages of civil aviation tilt-rotor commuter aircraft. It is anticipated that the availability of tilt-rotor aircraft capable of seating, in various scalings, from six to 100 passengers, will greatly extend the efficiency and economical service life of current airports by reducing traffic congestion. Attention is given to operational schemes involving the feeding of passengers from smaller urban areas to large hub cities, as well as commuter transportation among cities with tilt-rotor 'vertiport' facilities located over highway networks. Particular benefits are seen from tilt-rotors' reduction of noise-footprint profiles, by comparison with those of fixed-wing aircraft. O.C.

A90-30222
FLY-BY-WIRE CONTROLS KEY TO 'PURE' STEALTH AIRCRAFT
MICHAEL A. DORNHEIM Aviation Week and Space Technology (ISSN 0005-2175), vol. 132, April 9, 1990, p. 36, 37, 40, 41.
Copyright

Various aspects of stealth fighter configuration developed around the primary requirement of achieving a minimal radar cross section (RCS) are presented. The F-117A design originated at a time when FBW technology had matured sufficiently to warrant using it on production aircraft. Factors that influenced the final design of the stealth aircraft include: use of various coatings and materials tuned to absorb radar over a wide range of frequencies, overall configuration composed of flat panels, engine inlets and the top of the fuselage aligned with the wing leading edge and the exhaust nozzles aligned with the outboard trailing edge, engine inlets with radar-absorbtive composite mesh, wide, and thin exhaust ducts having extended and upturned bottom edges. It is noted that all of the RCS factors are continuously being improved and much of this advanced development can be observed in the design of the B-2 stealth bomber. R.E.P.

A90-30275
FUNDAMENTALS OF THE DESIGN AND DEVELOPMENT OF PARTS AND MECHANISMS FOR FLIGHT VEHICLES [OSNOVY RASCHETA I KONSTRUIROVANIIA DETALEI I MEKHANIZMOV LETATEL'NYKH APPARATOV]
NATAL'IA A. ALEKSEEVA, LEV A. BONCH-OSMOLOVSKII, VIKTOR V. VOLGIN, P. P. DEMENT'EV, V. V. DZHAMAI et al. Moscow, Izdatel'stvo Mashinostroenie, 1989, 456 p. In Russian. refs
Copyright

Performance criteria are presented for the parts and mechanisms of flight vehicles. Requirements for structural materials and their characteristics are reviewed, and the principles of the design and development of mechanical transmissions and their components and mechanisms are discussed with emphasis on the use of computer-aided design. The design of a variety of mechanisms for flight vehicles is illustrated by specific examples. V.L.

A90-31246#
HTTB - INDUSTRY'S FIRST STOL TEST BED
THOMAS SULLIVAN (Lockheed Aeronautical Systems Co., Burbank, CA) Aerospace America (ISSN 0740-722X), vol. 28, April 1990, p. 34-36, 38.
Copyright

The High Technology Test Bed (HTTB) program to develop technologies to meet future tactical airlift requirements is discussed. The program uses a modified C-130 transport with a real-time data acquisition system as a test bed to develop technologies for STOL missions. The process of modifying the aircraft is examined, including alterations of the control surfaces and mechanical flight controls, the use of chlorotrifluoroethylene in the hydraulic systems to power the spoilers, modifications to the aircraft turboprops system, and extending the flight envelope using a digital flight control system. The HTTB configuration is illustrated and the aircraft's navigation sensors, real-time data acquisition system, and data processing center are described. R.B.

A90-31284*# Massachusetts Inst. of Tech., Cambridge.
FLIGHT TESTING A HIGHLY FLEXIBLE AIRCRAFT - CASE STUDY ON THE MIT LIGHT EAGLE
S. H. ZERWECKH, A. H. VON FLOTOW (MIT, Cambridge, MA), and J. E. MURRAY (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 27, April 1990, p. 342-349. Previously cited in issue 21, p. 3487, Accession no. A88-50613. refs
Copyright

N90-18385*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FUSELAGE DESIGN FOR A SPECIFIED MACH-SLICED AREA DISTRIBUTION
RAYMOND L. BARGER and MARY S. ADAMS Washington Feb. 1990 88 p
(NASA-TP-2975; L-16651; NAS 1.60:2975) Avail: NTIS HC A05/MF A01 CSCL 01/3

A procedure for designing a fuselage having a prescribed effective area distribution computed from -90 deg Mach slices is described. This type of calculation is an essential tool in designing a complete configuration with an effective area distribution that corresponds to a desired sonic boom signature shape. Sample calculations are given for $M=2$ and $M=3$ designs. The examples include fuselages constrained to have circular cross sections and fuselages having cross sections of arbitrary shape. It is found that, for a prescribed effective area distribution having sharp variations, the iterative procedure converges to a smoothed approximation to the prescribed distribution. For a smooth prescribed area distribution, the solution is not unique. Author

N90-18386# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
VISUAL SERVOING FOR AUTONOMOUS AIRCRAFT REFUELING M.S. Thesis
RICHARD P. SHIPMAN 14 Dec. 1989 92 p
(AD-A216042; AFIT/GE/ENG/89D-48) Avail: NTIS HC A05/MF A01 CSCL 23/3

The design and development of autonomous robotic systems for autonomous aircraft refueling is a major interest to the Air Force. The approach being undertaken is the integration of vision and robot technologies allowing visual information, regarding identification and location of an aerial refueling receptacle on an aircraft, to be fed back to a robot controller which develops trajectory information needed for compliant robot motion. The purpose was to modify, develop, and evaluate existing visual processing algorithms to allow the AFIT PUMA-560 to visually acquire and track a half-scale mock-up UARRSI aerial refueling receptacle, and place a simulated refueling nozzle in the close proximity of the receptacle's slipway. This was accomplished by developing visual object recognition and robot serving algorithms which: analyzed images, recognizes and determined the position of the receptacle, and calculated proper PUMA joint angles for end-effector placement. Based on this approach, a static look-and-move robotic visual serving system (RVSS) was demonstrated which: identified, located, and served the PUMA's end-effector to the close proximity of the refueling receptacle. The RVSS provides the visual recognition and serving necessary so that when combined with a compliant motion controller completes the insertion task, thereby completely demonstrating the AFIT concept for robot refueling. In addition, the initial architecture for a dynamic look-and-move RVSS was developed based on parallel processing. GRA

N90-18387# Arnold Engineering Development Center, Arnold Air Force Station, TN.
THE EFFECTS OF WIND TUNNEL DATA UNCERTAINTY ON AIRCRAFT POINT PERFORMANCE PREDICTIONS Final Report, Oct. 1988 - Sep. 1989
J. D. CLOYD Dec. 1989 51 p Submitted for publication
(AD-A216091; AEDC-TR-89-14) Avail: NTIS HC A04/MF A01 CSCL 01/1

A study was conducted to determine the effects of uncertainties in wind tunnel test data on the point performance predictions for a typical fighter at medium altitude and subsonic velocity. The equations of motion of selected parameters were formulated in terms of the aerodynamic coefficients and thrust model. A computer code was written to calculate the performance parameters from the aerodynamic and thrust model inputs. An aerodynamic model closely approaching a typical fighter flying at 30,000 ft mean sea level was developed from wind tunnel, flight test, and flight manual data. The effects of the uncertainties in the aerodynamic coefficients on the performance parameters were determined by varying the aerodynamic coefficients input to the computer code. GRA

N90-18388# Bihrle Applied Research, Inc., Jericho, NY.
INFLUENCE OF FOREBODY GEOMETRY ON AERODYNAMIC CHARACTERISTICS AND A DESIGN GUIDE FOR DEFINING DEPARTURE/SPIN RESISTANT FOREBODY CONFIGURATIONS Final Report, Sep. 1986 - Feb. 1989
W. BIHRLE, JR., B. BARNHART, and E. DICKES Sep. 1989

295 p
(Contract F33615-86-C-3624)
(AD-A216714; BAR-89-3; WRDC-TR-89-3079) Avail: NTIS HC A13/MF A02 CSCL 01/1

The loss of airplanes and occupants attributable to departures from controlled flight and ensuing spins has been a problem since the earliest days of aviation. These losses have plagued both the military and general aviation communities. The phenomena responsible for such losses take on added significance because, in the past ten years, high angle-of-attack capability in the post-stall region has been shown to significantly enhance the air combat maneuvering effectiveness of fighter airplanes and, therefore, this is not a region to be avoided, but rather exploited, if possible. Fortunately, the aerodynamic characteristics that produce departures and spins have been identified within the past few years through rotary balance tests, which identify an airplane's aerodynamic characteristics in a steady rotational flow environment. It was demonstrated in the Phase 1 that the high angle-of-attack aerodynamic characteristics are very configuration dependent and that forebody geometry can have a significant influence on these characteristics. In the extreme case, an aircraft's undesirable aerodynamics can be completely attributable to the forebody. In this instance, autorotative yawing and rolling moments, as well as increasing nose-up pitching moments with increasing rotation rate, are realized. GRA

N90-18389# Army Aviation Research and Development Command, Moffett Field, CA. Aeroflight Dynamics Directorate.
TIME AND FREQUENCY-DOMAIN IDENTIFICATION AND VERIFICATION OF BO-105 DYNAMIC MODELS
JUERGEN KALETKA, WOLFGANG V. GRUENHAGEN (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick, Germany, F.R.), MARK B. TISCHLER, and JAY W. FLETCHER 15 Sep. 1989 26 p Presented at the 15th European Rotorcraft Forum, Amsterdam, Netherlands, 12-15 Sep. 1989
(AD-A216828) Avail: NTIS HC A03/MF A01 CSCL 01/3

Mathematical models for the dynamics of the DLR BO 105 helicopter are extracted from flight test data using two different approaches: frequency-domain and time-domain identification. Both approaches are reviewed. Results from an extensive data consistency analysis are given. Identifications for 6 degrees of freedom (DOF) rigid body models are presented and compared in detail. The extracted models compare favorably and their prediction capability is demonstrated in verification results. Approaches to extend the 6 DOF models are addressed and first results are presented. System identification is broadly defined as the deduction of system characteristics from measured data. It provides the only possibility to extract both non-parametric (e.g., frequency responses) and parametric (e.g., state space matrices) aircraft models from flight test data and therefore gives a reliable characterization of the dynamics of the actually existing aircraft. Main applications of system identification are seen in areas where higher accuracies of the mathematical models are required: Simulation validation, control system design (in particular model-following control system design for in-flight simulation), and handling qualities. GRA

N90-18390*# Ohio State Univ., Columbus. ElectroScience Lab.
A USER'S MANUAL FOR THE METHOD OF MOMENTS AIRCRAFT MODELING CODE (AMC) Final Report
M. E. PETERS and E. H. NEWMAN Sep. 1989 193 p
(Contract NSG-1498)
(NASA-CR-186371; NAS 1.26:186371; FR-716199-14) Avail: NTIS HC A09/MF A01 CSCL 01/3

This report serves as a user's manual for the Aircraft Modeling Code or AMC. AMC is a user-oriented computer code, based on the method of moments (MM), for the analysis of the radiation and/or scattering from geometries consisting of a main body or fuselage shape with attached wings and fins. The shape of the main body is described by defining its cross section at several stations along its length. Wings, fins, rotor blades, and radiating monopoles can then be attached to the main body. Although AMC was specifically designed for aircraft or helicopter shapes, it can also be applied to missiles, ships, submarines, jet inlets, automobiles, spacecraft, etc. The problem geometry and run control parameters are specified via a two character command language input format. The input command language is described and several examples which illustrate typical code inputs and outputs are also included. Author

N90-18391# Institut Franco-Allemand de Recherches, Saint-Louis (France).
STUDY OF THE BLADE/VORTICE INTERACTION ON A ONE-BLADE ROTOR DURING FORWARD FLIGHT (INCOMPRESSIBLE, NON VISCOUS FLUID) [ETUDE DE L'INTERACTION PALE/TOURBILLON SUR UN ROTOR MONOPALE EN VOL D'AVANCEMENT (FLUIDE NON VISQUEUX ET INCOMPRESSIBLE)]
M. SCHAFFAR and J. HAERTIG 19 Aug. 1988 54 p In FRENCH Original contains color illustrations
(ISL-R-115/88; ETN-90-96237) Avail: NTIS HC A04/MF A01

The applications of two and three dimensional numerical methods to the profile/vortice are reviewed. An application of the vortical network method to a rotor, during steady and forward flight, is presented. It is shown that the simultaneous use of the vortical network method and the conformal transformation can be applied to a thick rotor case, and the pressure coefficients can be calculated and used in acoustical analysis. The influence of the height, the vortice intensity and the angle between the blade and the vortice are studied. ESA

N90-18392# Institut Franco-Allemand de Recherches, Saint-Louis (France).
POSSIBLE PILOTING TECHNIQUES AT HYPERSONIC SPEEDS [LENKMOEGLICHKEITEN IM HYPERSCHALL]
K. W. NAUMANN 20 Jun. 1988 75 p In GERMAN
(ISL-CO-216/88; ETN-90-96244) Avail: NTIS HC A04/MF A01

The laws determining gas flow at hypersonic speeds are reviewed. Different piloting techniques presently known and considered promising for use in hypersonic flight are outlined. A detailed explanation of piloting techniques using lateral jets, or a combined control using flaps and jets, is presented. The general direction in which piloting research is heading is described. The improvements needed in each of the different piloting techniques presented are outlined. ESA

N90-19224*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
COMPENSATING FOR PNEUMATIC DISTORTION IN PRESSURE SENSING DEVICES
STEPHEN A. WHITMORE and CORNELIUS T. LEONDES (California Univ., Los Angeles.) Jan. 1990 21 p Presented at the AIAA 28th Aerospace Sciences Meeting, Reno, NV, 8-11 Jan. 1990 Previously announced in IAA as A90-19956
(NASA-TM-101716; H-1586; NAS 1.15:101716) Avail: NTIS HC A03/MF A01 CSCL 01/3

A technique of compensating for pneumatic distortion in pressure sensing devices was developed and verified. This compensation allows conventional pressure sensing technology to obtain improved unsteady pressure measurements. Pressure distortion caused by frictional attenuation and pneumatic resonance within the sensing system makes obtaining unsteady pressure measurements by conventional sensors difficult. Most distortion occurs within the pneumatic tubing which transmits pressure impulses from the aircraft's surface to the measurement transducer. To avoid pneumatic distortion, experiment designers mount the pressure sensor at the surface of the aircraft, (called in-situ mounting). In-situ transducers cannot always fit in the available space and sometimes pneumatic tubing must be run from the aircraft's surface to the pressure transducer. A technique to measure unsteady pressure data using conventional pressure sensing technology was developed. A pneumatic distortion model is reduced to a low-order, state-variable model retaining most of the dynamic characteristics of the full model. The reduced-order model is coupled with results from minimum variance estimation theory to develop an algorithm to compensate for the effects of pneumatic distortion. Both postflight and real-time algorithms are developed and evaluated using simulated and flight data. Author

N90-19225*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
X-29A AIRCRAFT STRUCTURAL LOADS FLIGHT TESTING
ROBERT SIMS, PAUL MCCROSSON, ROBERT RYAN, and JOE RIVERA (Grumman Aerospace Corp., Edwards, CA.) Dec. 1989 37 p Presented at the 20th Annual Society of Flight Test Engineers Symposium, Reno, NV, 18-21 Sep. 1989
(NASA-TM-101715; H-1574; NAS 1.15:101715) Avail: NTIS HC A03/MF A01 CSCL 01/3

The X-29A research and technology demonstrator aircraft has completed a highly successful multiphase flight test program. The primary research objective was to safely explore, evaluate, and validate a number of aerodynamic, structural, and flight control technologies, all highly integrated into the vehicle design. Most of these advanced technologies, particularly the forward-swept-wing platform, had a major impact on the structural design. Throughout the flight test program, structural loads clearance was an ongoing activity to provide a safe maneuvering envelope sufficient to accomplish the research objectives. An overview is presented of the technologies, flight test approach, key results, and lessons learned from the structural flight loads perspective. The overall design methodology was considered validated, but a number of structural load characteristics were either not adequately predicted or totally unanticipated prior to flight test. While conventional flight testing techniques were adequate to insure flight safety, advanced analysis tools played a key role in understanding some of the structural load characteristics, and in maximizing flight test productivity. Author

N90-19226*# Analytical Services and Materials, Inc., Hampton, VA.
PERFORMANCE OF AN OPTIMIZED ROTOR BLADE AT OFF-DESIGN FLIGHT CONDITIONS
ADITI CHATTOPADHYAY Washington NASA Mar. 1990 17 p Presented at the AHS Vertical Lift Aircraft Design Conference, San Francisco, CA, 17-19 Jan. 1990
(Contract NAS1-18599)
(NASA-CR-4288; NAS 1.26:4288) Avail: NTIS HC A03/MF A01 CSCL 01/3

An investigation is made of the dynamic and aerodynamic performance of a helicopter rotor previously optimized for minimum 4/rev vertical shear and blade weight subject to certain dynamic and structural constraints. The program CAMRAD which was used in designing the optimized blade is used for both dynamic and aerodynamic analaysis. The behavior of the optimized rotor is analyzed over a wide range of operating conditions and for a larger number of rotor characteristics than those considered in designing the blade. To assess the dynamic behavior, the blade root vibratory shears and moments that are transmitted to the rotor hub are calculated. The aerodynamic performance assessments are made based on the power required by the rotor for a given rotor task, the rotor lifting efficiencies, maximum rotor thrust envelopes and the control margins. Results are presented for the optimized blade and the control margins. Results are presented for the optimized blade and the reference blade, which was used as the baseline for the optimized blade, for two rotor tasks. Author

N90-19227*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AEROSERVOELASTICITY
THOMAS E. NOLL Mar. 1990 13 p Presented at the AIAA 31st Structures, Structural Dynamics, and Materials Conference, Long Beach, CA, 2-4 Apr. 1990
(NASA-TM-102620; NAS 1.15:102620) Avail: NTIS HC A03/MF A01 CSCL 01/3

Accomplishments and current research projects along four main thrusts in aeroservoelasticity at the NASA Langley Research Center are described. One activity focuses on enhancing the modelling and the analysis procedures to accurately predict aeroservoelastic interactions. In the area of modelling, improvements to the minimum-state method of approximating unsteady aerodynamics are shown to provide precise, low-order models for design and simulation tasks. Recent extensions in aerodynamic correction factor methodology are also described. With respect to analysis procedures, the paper reviews novel enhancements to Matched Filter Theory and Random Process Theory for predicting the critical gust profile and the associated time-correlated gust loads for structural design considerations. In another activity, two research projects leading towards improved design capability are summarized. The first program involves the development of an integrated structure/control design capability; the second provides procedures for obtaining low-order, robust digital control laws for aeroelastic applications. Experimental validation of new theoretical developments is the third activity. As such, a short description of the Active Flexible Wing Project is presented, and recent wind-tunnel test accomplishments are summarized. Finally within the area of application, a study performed to assess the state-of-the-art of aeroelastic and aeroservoelastic analysis and design technology with respect to hot, hypersonic flight vehicles is reviewed. Author

N90-19228# National Aerospace Lab., Amsterdam (Netherlands). Materials and Structures Div.
STATIC STRENGTH AND DAMAGE TOLERANCE TESTS ON THE FOKKER 100 AIRFRAME
H. VLIEGER Mar. 1988 16 p In DUTCH; ENGLISH summary Presented at the NVvL-VSV Symposium Certificatie van Vliegtuigen, Delft, Netherlands, 29 Apr. 1988
(Contract NIVR-06501N)
(NLR-MP-88023-U; ETN-90-95419) Avail: NTIS HC A03/MF A01

A full scale static and flight simulation fatigue test program was performed on the airframe of the Fokker 100 to show compliance with the requirements of the airworthiness authorities regarding static strength and damage tolerance of a new design. The aircraft was split up into a number of specimens, each constituting a major assembly of the total airframe. The tests carried out on one of the specimen (the horizontal stabilizer) are described. The design of the test rig and the load introduction system, the loading program for static and flight simulation testing, the load control during testing, and the various measurements are discussed. The preliminary testing results are presented. ESA

N90-19229# Technische Univ., Brunswick (Germany, F.R.). Fakultaet fuer Maschinenbau und Elektrotechnik.
CALCULATION AND OPTIMIZATION OF ROTOR START PROCESS Ph.D. Thesis [EIN BEITRAG ZUR BERECHNUNG UND OPTIMIERUNG VON HUBSCHRAUBER-STARTVERFAHREN]
THOMAS CERBE 1989 138 p In GERMAN
(ETN-90-95894) Avail: NTIS HC A07/MF A01

Appropriate simulation models are developed for the calculation and the optimization of rotor start process and the checkout by flight tests. The quasi stationary model needs a calculation time ten times lower than the simulated real time. For the ground effect in forward flight a half-empirical model is integrated into the rotor calculation. The dynamic ground effect is taken into account in the slow flight area by a filter of first order. The comparison of the different simulations shows a very good estimation of the power needs. The total simulation of the longitudinal motion and the characteristic field show negligible differences of power. Several decisive points for the start of a rotor are obtained, that are dependent on the plane mass, the start power, and the atmospheric conditions. A critical decisive velocity is established that is similar to the flight velocity for minimal ascent. ESA

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A90-28209

A REVIEW OF THE V-22 HEALTH MONITORING SYSTEM

MICHAEL J. AUGUSTIN and GARY D. MIDDLETON (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 757-769.

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This paper reviews the design of the V-22 health monitoring system. The two primary systems discussed include an onboard reporting system called the Central Integrated Checkout system or CIC, and a dedicated system called the Vibration, Structural Life, and engine Diagnostic system or VSLED for attaining both inflight and postflight maintenance objectives. The paper describes CIC's role in establishing the operational status of the aircraft and VSLED's role in supporting the on-condition maintenance concept. It reviews the techniques used to implement these concepts in the V-22's engines, airframe, drive train, proprotors, and a number of life-limited dynamic components. It also describes a VSLED function that calculates track and balance adjustments for the proprotors. Author

A90-28217

AVIONICS AND ELECTROMAGNETIC COMPATIBILITY (EMC) CONSIDERATIONS ON A HELICOPTER WITH AN ADVANCED COMPOSITE AIRFRAME

G. W. OSBORNE (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 879-884.

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Bell Helicopter Textron Inc. has designed and built a large number of conventional all-metal helicopters. The company has designed and tested integrated avionics systems for them, and evaluated the relationships between their airframes and electromagnetic and electrical phenomena, making adjustments where necessary. More recently the company has found itself applying its experience in this area to aircraft such as the ACAP and V-22, which have composite or mostly composite airframes. The composite airframe has a markedly different effect on electromagnetic compatibility and interference. This paper describes the differences and some of the things BHTI has done to take advantage of or compensate for them. Author

A90-28218

HELICOPTER OBSTACLE AVOIDANCE SYSTEM - THE USE OF MANNED SIMULATION TO EVALUATE THE CONTRIBUTION OF KEY DESIGN PARAMETERS

P. H. CERCHIE, A. CLYDE FLACKBERT (McDonnell Douglas Helicopter Co., Mesa, AZ), and DONALD REAGO (U.S. Army, Center for Night Vision and Electro-Optics, Fort Belvoir, VA) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 885-890.

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An ongoing man-in-the-loop simulation experiment is described. The object of the experiment is to examine selected design variables related to helicopter obstacle avoidance systems. Four candidate sensor models differing in field-of-view, frame rate, stabilization, slewing method, and detection range are defined. The study focuses on the use of a dome display helicopter simulator with host software and a visual data base specifically designed for trials simulating high-speed contour night flight. The 30 x-40-deg Integrateed Helmet and Display Sight System (IHADSS) forward-looking IR display provides all visual cues. Author

A90-28221

DESIGN CRITERIA FOR HELICOPTER NIGHT PILOTAGE SENSORS

RICHARD H. VOLLMERHAUSEN and CAROLYN J. NASH (U.S. Army, Center for Night Vision and Electro-Optics, Fort Belvoir, VA) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 911-919. refs

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The results are reported of research conducted to establish criteria for the design of night vision pilotage aids. It is shown that terrain flight can be accomplished with reasonable pilot workload using a sensor with 40 deg FOV and 0.6 cycles per milliradian resolution. This resolution is important and should not be traded for increased FOV. Further, a pilotage system which provides both thermal and I-squared imagery will significantly enhance system capability to support a variety of flight tasks under a wide range of environments. It is also concluded that solid state cameras with detector dwell time equal to the standard video field rate are not suitable for use in pilotage systems. The long dwell time leads to image blur due to the head and scene motion associated with many pilotage tasks. C.D.

A90-28291

DEVELOPMENT OF TWO MULTI-SENSOR HOT-FILM MEASURING TECHNIQUES FOR FREE-FLIGHT EXPERIMENTS

F. FEYZI, M. KORNBERGER (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany), N. RACHOR, and B. ILK (Darmstadt, Technische Hochschule, Federal Republic of Germany) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 443-449. refs

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Measuring techniques are described which can be used in free-flight conditions to detect the transition region and measure the skin friction for laminar wings. Particular attention is given to two multisensor hot-film techniques being developed and tested in a wind tunnel and on a power glider in free flight: (1) a technique based on constant-temperature anemometry and (2) a technique based on constant-current anemometry. The probe for (1) is composed of commercially available hot films; FFT analysis of the signals makes it possible to determine laminar, transitional, and turbulent flow in the boundary layer and to detect instabilities such as Tollmien-Schlichting waves. Skin friction could be measured if a suitable calibrating method can be found. Technique (2) is being developed in order to increase the number of sensors for simultaneous measurements in wind tunnels. I.E.

A90-28407

PATTERN REPRESENTATIONS AND SYNTACTIC CLASSIFICATION OF RADAR MEASUREMENTS OF COMMERCIAL AIRCRAFT

O. S. SANDS and F. D. GARBER (Ohio State University, Columbus) IEEE Transactions on Pattern Analysis and Machine Intelligence (ISSN 0162-8828), vol. 12, Feb. 1990, p. 204-211. refs

(Contract N00014-86-K-0202)

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A syntactic pattern recognition system is evaluated for applications to radar signal identification. Three different level-crossing-based pattern representation algorithms are considered. The utility of the resulting symbolic pattern representations is assessed by evaluating the performance of a maximum-likelihood classifier when the observed symbol strings are used as inputs to the decision algorithm. A syntax analysis algorithm is derived from the likelihood function classifier. Performance results of simulated classification experiments for both maximum-likelihood and language-theoretic classifiers are presented. I.E.

A90-28849
THE ROTOR-SIGNAL-MODULE OF MFI90
RAINER HOLLAND (DLR, Institut fuer Flugmechanik, Brunswick, Federal Republic of Germany) IN: ITC/USA/'89; Proceedings of the International Telemetering Conference, San Diego, CA, Oct. 30-Nov. 2, 1989. Research Triangle Park, NC, Instrument Society of America, 1989, p. 315-324. refs
Copyright
Instrumentation developed for the acquisition of rotor data from a BO105 helicopter is presented with a view to the design of its digital data acquisition and processing hardware, which was shaped by the limited space available on the system's mounting atop the main rotor hub. Attention is given to the method used for calibrating the measurement values from the rotor blades; data quality is evaluated by comparing measured rotor characteristics to the results of a nonlinear helicopter computer simulation. O.C.

A90-28850
THE MODULAR FLIGHTTEST INSTRUMENTATION/MFI 90 - A HELICOPTER MEASURING SYSTEM
HORST MEYER (DLR, Institut fuer Flugmechanik, Brunswick, Federal Republic of Germany) IN: ITC/USA/'89; Proceedings of the International Telemetering Conference, San Diego, CA, Oct. 30-Nov. 2, 1989. Research Triangle Park, NC, Instrument Society of America, 1989, p. 325-333.
Copyright
The Modular Flight-test Instrumentation 90 (MFI 90) system for measuring the stability/control characteristics of helicopters is designed to handle a limited (64-128) number of low-to-medium bandwidth signals. Because the MFI 90 is modular in architecture, it is highly adaptable and has consistent yielded problem-oriented configurations; it also operates reliably under rough testing conditions. The modest cost of the system is a consequence of its use of off-the-shelf, commercial standard interfaces for communication and general-purpose components. O.C.

A90-28874
AIRBORNE TELEMETRY TRENDS FOR THE 1990'S
RICHARD E. VAN DOREN (Aydin Corp., Vector Div., Newtown, PA) IN: ITC/USA/'89; Proceedings of the International Telemetering Conference, San Diego, CA, Oct. 30-Nov. 2, 1989. Research Triangle Park, NC, Instrument Society of America, 1989, p. 561-574. refs
Copyright
This paper reviews the evolution of the airborne telemetry hardware technology, from the early telemetry systems of the 1960s to the high-performing systems of the late 1980s. It is shown that, during these years, the trends have produced flight hardware of increasingly higher performance, flexibility, reliability, and power efficiency, while achieving smaller size and weight. The test program requirements have become more complex, from the application and the programming requirements and the quality assurance requirements, to the complex procurement process, export and import license laws and procedures, and other regulations, making it very difficult for the innovative technologist to compete and survive. It is emphasized that there is a need for reducing the administrative and procedural burdens on the flight test community and the telemetry industry which discourage the technologists from creativity and impose increased costs and procurement/delivery cycles on the industry. I.S.

A90-28895
DEVELOPMENT OF AIRBORNE DATA REDUCTION SYSTEM IN IPTN FLIGHT TEST
F. X. SUDHARMONO, HARIANTO KONSTYONO, and ARDJUNA THALIB (Nusantara Aircraft Industries, Ltd., Bandung, Indonesia) IN: ITC/USA/'89; Proceedings of the International Telemetering Conference, San Diego, CA, Oct. 30-Nov. 2, 1989. Research Triangle Park, NC, Instrument Society of America, 1989, p. 783-795. refs
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This paper describes an airborne data reduction system using personal computer which was developed to enhance test-flight capabilities in remote area operations, where telemetry link from the test aircraft to the base station cannot be established. The development plan of this system consists of several phases. In the present preliminary phase, where areas of improvement are still wide open, experience during flight test execution will dictate the improvements to be introduced in later stages. The system can handle on-line flight data, and reduce it, display, and print in the form of tables, bar charts, or graphics. In the final phase, the system is expected to be able to perform the flight test preparations including the check-out of the measuring parameters check-out, to reduce and present the data in real-time, to record all the information, and to prepare a flight test report and facilitate a post-flight check-out. I.S.

A90-29943
METEOPOD, AN AIRBORNE SYSTEM FOR MEASUREMENTS OF MEAN WIND, TURBULENCE, AND OTHER METEOROLOGICAL PARAMETERS
PETER VOERSMANN (Aerodata Flugmesstechnik GmbH, Brunswick, Federal Republic of Germany) L'Onde Electrique (ISSN 0030-2430), vol. 70, Mar.-Apr. 1990, p. 31-38. refs
Copyright
In Meteopod, all the components are integrated in an external pod for aircraft and helicopter applications. This pod solution includes a software and hardware concept which makes it possible to determine all three wind-vector components in real time on board the aircraft. Flight-test results are presented which demonstrate attainable accuracies for the horizontal and vertical wind components; this includes the effects of dynamic aircraft maneuvers. Finally, predictions are made as to what kind of precision can be achieved in the future, when satellite navigation systems will be available on a 24-hour basis. B.J.

A90-30238#
INFORMATION DISPLAY MANAGEMENT IN A PILOT'S ASSOCIATE
CHARLES W. HOWARD, JOHN M. HAMMER, and NORMAN D. GEDDES (Search Technology, Inc., Norcross, GA) IN: AAAIC '88 - Aerospace Applications of Artificial Intelligence; Proceedings of the Fourth Annual Conference, Dayton, OH, Oct. 25-27, 1988. Volume 1. Xenia, OH, Dayton SIGART, 1988, p. 339-348. Research supported by Lockheed-Georgia Co. refs
(Contract F33615-85-C-3804)
An artificially intelligent information management system (IM) that automatically selects the optimal type, amount, and placement of information that would be a beneficial aid to the pilot is proposed. The goal of the IM is to display information to best fit the situation and the pilot's resource capabilities. This is accomplished by integrating the information requirements and allocating space to required topics, locating and partitioning the physical display devices into logical devices for the topics, and assigning displays to the logical devices. The IM uses many different artificial intelligent techniques to present information to the pilot. Constraint based reasoning is used for space allocation while location of space is decided by rule-based reasoning. Finally, the selection of displays is done by heuristic assignment. R.E.P.

A90-30681
BUBBLE MEMORY APPLICATIONS FOR AIRCRAFT SYSTEMS
JIM GESNER and BILL MORRISON (Magnesys, Santa Clara, CA) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 59-62. refs
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The authors address the requirements for airborne storage and describe the optimal technology solution for various applications. For a number of airborne applications, bubble memory is shown to be the optimal technical solution. Because of the inherent ruggedness of solid-state devices, bubble memory can easily be used in the environment of high-stress aircraft maneuvers. The advantages bubble memory offers in airborne applications are described. I.E.

A90-30682#

TOWARD THE PANORAMIC COCKPIT, AND 3-D COCKPIT DISPLAYS

DAVID G. HARALSON, JOHN M. REISING, and JOSEPH GHRAYEB (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 80-85. refs

The authors present ongoing research at the Cockpit Integration Directorate to develop and mature large-area (panoramic) cockpit technology for transition to current and future military aircraft, and to evolve this technology into a three-dimensional (3-D) cockpit display for providing an optimum man-machine interface in future aircraft cockpits. A review of the Panoramic Cockpit Control and Display System (PCCADS) study and final results is presented, and current extensions to that effort are discussed. An assessment of display hardware technology and progress toward realizing a panoramic cockpit display are presented. Finally, related efforts to extend panoramic display technology to 3-D are examined. I.E.

A90-30694

A LASER OBSTACLE AVOIDANCE AND DISPLAY SYSTEM

M. L. BUSBRIDGE and D. J. PULESTON (GEC Avionics, Ltd., Airborne Display Div., Rochester, England) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 179-186.

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The authors describe an airborne laser system that provides a pilot with a display of obstacles such as power cables ahead of his aircraft. This system, LOCUS (Laser Obstacle and Cable Unmasking System), was flight-tested by the Naval Air Test Center at Patuxent River, where cable detection ranges of over 2 km were measured. It is found that real-time processing of the laser returns can achieve a real-time display of obstacles is the flight path sufficiently early to enable safe evasive action. In addition, real-time processing of the laser returns can provide unmapped obstacle data to enhance a digital terrain system in low-level covert terrain-following mode. I.E.

A90-30723

CHALLENGES OF TOMORROW - THE FUTURE OF SECURE AVIONICS

JOANN SWANGIM, JACK L. STRAUSS, THOMAS J. KOLKMEIER (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH), TERESA ACEVEDO, and ART FRIEDMAN (Booz, Allen, and Hamilton, Inc., Bethesda, MD) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 580-586. Research supported by USAF and Booz, Allen, and Hamilton, Inc.

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This paper identifies INFOSEC (information security) challenges specific to advanced avionics in military systems and presents a methodology for addressing these challenges. This methodology is based on a system engineering approach to integration of security with the advanced avionics. Also discussed is the trusted computing base as an emerging INFOSEC technology for providing security services in an advanced avionics architecture. The application of existing computer security guidelines, specifically the the National Computer Security Center Rainbow Series, is discussed in the context of an advanced avionics environment. I.E.

A90-30724

EMBEDDED COMPUTER SYSTEM INTEGRATION SUPPORT

RANDY E. PHILLIPS and MARK J. THULLEN (TRW, Inc., Military Electronics and Avionics Div., Beavercreek, OH) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 616-622.

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The Embedded Computer System Integration Support (ECSIS) family of system integration support products has been targeted to meet the instrumentation requirement of the distributed avionics architectures currently evolving. This family of products provides basic stand-alone capabilities as well as simple expansion through the addition of other family members to a test configuration. Descriptions are given of of the following processor and data bus monitor and control products: (1) X-TRAC, an embedded computer system (X) tool for real-time analysis and control; (2) X-PROBE, a user-friendly window-oriented monitor and control test-operator interface; and (3) X-PIM, personality interface modules which provide the custom interface for the X-TRAC to individual processor and data bus targets. I.E.

A90-30730#

DEVELOPMENT OF AN ACCEPTABILITY WINDOW FOR A GROUND PROXIMITY AVOIDANCE SYSTEM

JOHN A. HASSOUN (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 746-751.

An acceptability window for the F/FB/EF-111 aircraft has been developed which is based on pilots' subjective evaluations. As part of an overall evaluation of the F/FB/EF-111 GPWS (ground proximity warning system), subjective data were collected following the completion of each of a multitude of different configurations flown in an FB-111 simulator and analyzed using the multiple regression technique. The window of acceptability was developed using the minimum recovery altitude as a function of vertical velocity. The window was validated using performance data collected during the overall evaluation of the GPWS. I.E.

A90-30787

FLIGHT SIMULATOR EVALUATION OF A DOT-MATRIX DISPLAY FOR PRESENTATION OF APPROACH MAP FORMATS

JAMES A. UPHAUS, JR. (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH), MICHAEL C. REYNOLDS, and MONICA E. GROEGER (Midwest Systems Research, Dayton, OH) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 4. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 1725-1732. Research supported by FAA.

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It is noted that high-contrast ratios coupled with square pixel shape can make stair-step distortion easily noticeable (without antialiasing) on a medium-resolution dot-matrix display (64 pixel/in.). Eighteen USAF pilots evaluated two dot-matrix approach/landing formats (with stair-step distortion) while flying approaches in a fixed base simulator. Conventional HSI (horizontal situation indicator) and FLIP chart were used as a performance baseline. No statistically significant differences were found in objective pilot performance and workload data that could be directly attributed to stair-step distortion. Performance differences were found that could be attributed to format information content and display scale factor (pixels per degree). Questionnaire data show that pilots view stair-step distortion as moderately distracting in a few instances, sometimes only marginally distracting, and generally without impact. I.E.

A90-31329* Illinois Univ., Champaign.

COGNITIVE PERSPECTIVES ON MAP DISPLAYS FOR HELICOPTER FLIGHT

KELLY HARWOOD (Illinois, University, Champaign) IN: Human Factors Society, Annual Meeting, 33rd, Denver, CO, Oct. 16-20, 1989, Proceedings. Volume 1. Santa Monica, CA, Human Factors Society, 1989, p. 13-17. refs

(Contract NAG2-308)

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Currently accessible technologies are providing entirely new

display concepts for enhancing helicopter navigation. Yet the effectiveness of such displays depends on the extent to which they are configured according to principles from research on human performance. Computer generated map displays in the present study were configured according to previous research on maps, navigational problem solving, and spatial cognition in large scale environments. Interest centered on the representation of different spatial relationships that would best support helicopter navigational problem solving. One map display emphasized the global relationships between objects in the environment. The other map showed the pilot's relationship to objects as he traveled through the environment. Twenty skilled pilots used the maps to complete several navigational tasks that occurred within a realistic simulation program tailored for helicopter navigation. Findings indicate that the type of task and mode of flight (low level or Nap of the Earth (NOE)) are important determinants of map display effectiveness.
Author

A90-31331
3-D IN PICTORIAL FORMATS FOR AIRCRAFT COCKPITS
THOMAS C. WAY (Boeing Co., Seattle, WA) IN: Human Factors Society, Annual Meeting, 33rd, Denver, CO, Oct. 16-20, 1989, Proceedings. Volume 1. Santa Monica, CA, Human Factors Society, 1989, p. 23-27. refs
(Contract F33615-86-C-3601)
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Sixteen military pilots flew simulated air-to-air and air-to-ground missions in a simulated fighter-attack cockpit. Three of the five color CRTs in the cockpit were capable of displaying retinal disparity and the major independent variable was presence or absence of disparity. Performance, workload, and opinion data were collected. A second objective of the study was to continue development of the display formats, which had evolved through earlier projects. The disparity results and the recommended format revisions are presented. Author

A90-31333
THE EFFECT OF WINDSCREEN BOWS AND HUD PITCH LADDER ON PILOT PERFORMANCE DURING SIMULATED FLIGHT
JOHN E. DEATON, MICHAEL BARNES, NANCY LINDSEY, JANETTAROSE GREENE (U.S. Navy, Naval Air Development Center, Warminster, PA), and JONATHAN KERN (Veda, Inc., Warminster, PA) IN: Human Factors Society, Annual Meeting, 33rd, Denver, CO, Oct. 16-20, 1989, Proceedings. Volume 1. Santa Monica, CA, Human Factors Society, 1989, p. 33-37. refs
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Concerns expressed on the proposed use of the HUD as the primary flight reference instrument and associated problem areas are addressed. This study is twofold: to measure the levels of target detection with and without windscreen bows, and to measure unusual attitude recovery performance using two different HUD pitch ladder formats. During simulated flight, 12 subjects were required to make visual detections of enemy aircraft with and without the bows and were also required to recover from various pitch/roll combinations. It is noted that removal of the bows improved target detection. Evaluation of the two HUD pitch ladder formats revealed that, at severe negative pitch attitudes, there was a marked performance benefit with the enhanced HUD versus the standard HUD. Possible improvements in current HUD pitch ladder formats were suggested which would convey more cues to accurately and rapidly determine aircraft attitude. R.E.P.

A90-31344* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
HELMET MOUNTED DISPLAY SYSTEMS FOR HELICOPTER SIMULATION
LORAN A. HAWORTH, NANCY BUCHER (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA), and DAVID RUNNINGS (CAE Electronics, Ltd., Montreal, Canada) IN: Human Factors Society, Annual Meeting, 33rd, Denver, CO, Oct. 16-20, 1989, Proceedings. Volume 1. Santa Monica, CA, Human Factors Society, 1989, p. 86-90. refs
Copyright

Simulation scientists continually pursue improved flight simulation technology with the goal of closely replicating the 'real world' physical environment. The presentation/display of visual information for flight simulation is one such area enjoying recent technical improvements that are fundamental for conducting simulated operations close to the terrain. Detailed and appropriate visual information is especially critical for Nap-Of-the-Earth (NOE) helicopter flight simulation where the pilot maintains an 'eyes-out' orientation to avoid obstructions and terrain. This paper elaborates on the visually coupled Wide Field Of View Helmet Mounted Display (WFOVHMD) system technology as a viable visual display system for helicopter simulation. In addition the paper discusses research conducted on the NASA-Ames Vertical Motion Simulator that examined one critical research issue for helmet mounted displays.
Author

N90-18393*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A SIMULATION EVALUATION OF THE ENGINE MONITORING AND CONTROL SYSTEM DISPLAY
TERENCE S. ABBOTT Washington Feb. 1990 39 p Original contains color illustrations
(NASA-TP-2960; L-16637; NAS 1.60:2960) Avail: NTIS HC A03/MF A01; 6 functional color pages CSCL 01/4

The Engine Monitoring and Control System (E-MACS) display is a new concept for an engine instrument display, the purpose of which is to provide an enhanced means for a pilot to control and monitor aircraft engine performance. It provides graphically-presented information about performance capabilities, current performance, and engine component or subsystem operational conditions relative to nominal conditions. The concept was evaluated by sixteen pilot-subjects against a traditional, state-of-the-art electronic engine display format. The results of this evaluation showed a substantial pilot preference for the E-MACS display relative to the traditional display. The results of the failure detection portion of the evaluation showed a 100 percent detection rate for the E-MACS display relative to a 57 percent rate for the traditional display. From these results, it is concluded that by providing this type of information in the cockpit, a reduction in pilot workload and an enhanced ability for detecting degraded or off-nominal conditions is probable, thus leading to an increase in operational safety. Author

N90-18394*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THREE INPUT CONCEPTS FOR FLIGHT CREW INTERACTION WITH INFORMATION PRESENTED ON A LARGE-SCREEN ELECTRONIC COCKPIT DISPLAY
DENISE R. JONES Washington Apr. 1990 26 p
(NASA-TM-4173; L-16642; NAS 1.15:4173) Avail: NTIS HC A03/MF A01 CSCL 01/4

A piloted simulation study was conducted comparing three different input methods for interfacing to a large-screen, multiwindow, whole-flight-deck display for management of transport aircraft systems. The thumball concept utilized a miniature trackball embedded in a conventional side-arm controller. The touch screen concept provided data entry through a capacitive touch screen. The voice concept utilized a speech recognition system with input through a head-worn microphone. No single input concept emerged as the most desirable method of interacting with the display. Subjective results, however, indicate that the voice concept was the most preferred method of data entry and had the most potential for future applications. The objective results indicate that, overall, the touch screen concept was the most effective input method. There was also significant differences between the time required to perform specific tasks and the input concept employed, with each concept providing better performance relative to a specific task. These results suggest that a system combining all three input concepts might provide the most effective method of interaction. Author

N90-18395*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
WIND-TUNNEL INVESTIGATION OF A FLUSH AIRDATA SYSTEM AT MACH NUMBERS FROM 0.7 TO 1.4
TERRY J. LARSON, TIMOTHY R. MOES, and PAUL M. SIEMERS, III (National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.) Apr. 1990 35 p
(NASA-TM-101697; H-1544; NAS 1.15:101697) Avail: NTIS HC A03/MF A01 CSCL 01/4

Flush pressure orifices installed on the nose section of a 1/7-scale model of the F-14 airplane were evaluated for use as a flush airdata system (FADS). Wing-tunnel tests were conducted in the 11- by 11-ft Unitary Wind Tunnel at NASA Ames Research Center. A full-scale FADS of the same configuration was previously tested using an F-14 aircraft at the Dryden Flight Research Facility of NASA Ames Research Center (Ames-Dryden). These tests, which were published, are part of a NASA program to assess accuracies of FADS for use on aircraft. The test program also provides data to validate algorithms for the shuttle entry airdata system developed at the NASA Langley Research Center. The wind-tunnel test Mach numbers were 0.73, 0.90, 1.05, 1.20, and 1.39. Angles of attack were varied in 2 deg increments from -4 deg to 20 deg. Sideslip angles were varied in 4 deg increments from -8 deg to 8 deg. Airdata parameters were evaluated for determination of free-stream values of stagnation pressure, static pressure, angle of attack, angle of sideslip, and Mach number. These parameters are, in most cases, the same as the parameters investigated in the flight test program. The basic FADS wind-tunnel data are presented in tabular form. A discussion of the more accurate parameters is included. Author

N90-19417*# Mississippi State Univ., Mississippi State. Dept. of Computer Science.
MARSHALL AVIONICS TESTBED SYSTEM (MAST)
WAYNE D. SMITH *In* Alabama Univ., Research Reports: 1989 NASA/ASEE Summer Faculty Fellowship Program 39 p Dec. 1989
(Contract NGT-01-008-021)
Avail: NTIS HC A99/MF E06 CSCL 01/4

Work accomplished in the summer of 1989 in association with the NASA/ASEE Summer Faculty Research Fellowship Program at Marshall Space Flight Center is summarized. The project was aimed at developing detailed specifications for the Marshall Avionics System Testbed (MAST). This activity was to include the definition of the testbed requirements and the development of specifications for a set of standard network nodes for connecting the testbed to a variety of networks. The project was also to include developing a timetable for the design, implementation, programming and testing of the testbed. Specifications of both hardware and software components for the system were to be included. Author

07

AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

A90-27959#
EXPERIMENTAL AND THEORETICAL INVESTIGATIONS OF TURBULENT FLOW IN A SIDE-INLET RECTANGULAR CONBUSTOR
T.-M. LIOU (National Tsing Hua University, Hsinchu, Republic of China), S.-M. WU, and Y.-H. HWANG Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, Mar.-Apr. 1990, p. 131-138. refs
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Experimental and theoretical studies are reported on a turbulent flow in a side-inlet rectangular combustor with an aspect ratio of 4:1. A laser-Doppler velocimeter was used to measure the axial and transverse mean velocity and turbulence intensity components as well as Reynolds stress and turbulent kinetic energy. The Reynolds numbers based on the air density, combustor hydraulic diameter, and bulk velocity were in the range of 1000 to 200,000. The governing partial differential equations were solved numerically with the two-equation k-epsilon turbulence model. Reasonable agreement is demonstrated between the measured and calculated mean-velocity profiles. Flow oscillations are determined from the measured velocity probability density functions. Regions where turbulence is anisotropic and where turbulent kinetic energy and shear stresses dominate are identified. Author

A90-27962#
SWIRLING FLOW IN THRUST NOZZLES
H. DOYLE THOMPSON and JOE D. HOFFMANN (Purdue University, West Lafayette, IN) Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, Mar.-Apr. 1990, p. 151-157. Research supported by USAF. refs

This paper investigates the effects of adding swirl to a dump combustor-nozzle propulsion system. The results of cold-flow testing are summarized and compared to a numerical analysis of the nozzle flowfield. The cold-flow testing included thrust, mass flow rate, and pressure measurements for two different conical nozzle in combination with four swirlers, one of which was a blank. Five-port probe measurements were made across the nozzle entrance. The measurements were used to determine the stagnation pressure and swirl distributions and to provide initial conditions for a nozzle analysis program. The measured results show that swirl has a strong effect on the stagnation pressure distribution. The largest losses occur near the swirl axis. Swirl also significantly reduces the system discharge coefficients. In contrast, the effect of swirl on the nozzle stream thrust efficiency was small, but measurable. Swirl reduced the nozzle stream thrust efficiency by about 0.5 percent for the highest swirl tested. Computed nozzle flowfields that do not account for the stagnation pressure distribution in the swirling flow can produce highly distorted and unrealistic results. Comparison of measured and computed results (which use measured stagnation pressure and swirl distributions) shows reasonable agreement. Author

A90-27963#
USE OF SWIRL FOR FLOW CONTROL IN PROPULSION NOZZLES
K. KNOWLES (Royal Military College of Science, Shrivenham, England) and P. W. CARPENTER (Exeter, University, England) Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, Mar.-Apr. 1990, p. 158-164. Previously cited in issue 18, p. 2996, Accession no. A88-44722. refs
Copyright

A90-27972#
SMALL GAS TURBINE USING A SECOND-GENERATION PULSE COMBUSTOR
J. A. C. KENTFIELD (Calgary, University, Canada) and M. J. O'BLENES Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, Mar.-Apr. 1990, p. 214-220. Previously cited in issue 20, p. 3159, Accession no. A87-45440. refs
(Contract NSERC-A-7928)
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A90-28168
ADAPTIVE ELECTIVE FUEL CONTROL TEST TECHNIQUES
CHARLES E. GREENBERG (Sikorsky Aircraft, West Palm Beach, FL) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 229-234. refs
(Contract DAAJ02-86-C-0014)
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Testing modern digital electronic fuel control requires employing techniques which make the testing safe, efficient, and accurate. The recent Army/Sikorsky/Chandler Evans adaptive fuel control program incorporated software monitoring and modification capabilities, as well as a unique dual control installation to develop and test the control. In-flight utilization of these capabilities as well as innovative mission task evaluations yielded a productive test program. Consideration should be given to application of these techniques to future digital control development. Author

A90-28177
THE LHTEC T800-LHT-800 ENGINE INTEGRATION INTO THE AGUSTA A129 HELICOPTER
R. DAVID TOMS, JR. (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) and GIANFRANCO GODIO (Costruzioni Aeronautiche Giovanni Agusta S.p.A., Cascina Costa, Italy) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 339-350.
Copyright
Agusta and the Light Helicopter Turbine Engine Company (LHTEC, a partnership between Allison and Garrett turbine engine companies) joined together to install the T800-LHT-800 engine into the A129 aircraft. The airframe was modified to accept the generic T800 preliminary flight rating (PFR) engine. Agusta modified its main rotor transmission inputs to accommodate the counterclockwise (CCW) rotation of the T800 engine. An Agusta-provided drive shaft and aircraft inlet were successfully rig tested at LHTEC (Allison). In addition, an MIL-STD-1553 data bus was installed in the aircraft and Honeywell supplied a bus controller and a multifunctional display, which was used to transmit and display engine and airframe parameters. Testing of the bus controller using simulation was successfully completed at Honeywell. The engine and bus controller system, using an aircraft interface simulation (AIS) panel to simulate the aircraft inputs, were run in an engine test cell. In addition, dynamic modeling and closed loop bench testing were successfully completed. The total system was then incorporated at the Agusta facility and ground testing was performed. Initial ground and flight testing was completed successfully. Author

A90-28178
FLIGHT TESTING OF THE CHANDLER EVANS ADAPTIVE FUEL CONTROL ON THE S-76A HELICOPTER
DAVID H. SWEET (Sikorsky Aircraft, West Palm Beach, FL) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 351-365. refs
(Contract DAAJ02-86-C-0014)
Copyright
A full authority digital electronic control (FADEC) incorporating unique state-of-the-art adaptive features was flight tested on the S-76A helicopter. This paper presents the advantages and disadvantages of an adaptive control to manage the twin engine response of a modern, lightweight, highly maneuverable aircraft. For comparative purposes, reference will be made to the production engine hydro-pneumatic fuel control, uniquely installed in tandem with the experimental adaptive control, whose characteristics represent the majority of engine management systems currently in use. Details to be presented will substantiate a 3:1 improvement in engine power turbine governing when operating in the adaptive control mode. Additional flight test information will also investigate the automatic engine surge protection feature (adaptive control of the acceleration schedule) and automatic fuel consumption minimization by varying main rotor RPM. In conclusion, flight test substantiated recommendations will be presented that will detail the future usage and expected benefits on the performance and operational characteristics of advanced powerplants to be derived from adaptive control technology. Author

A90-28181
A COMPREHENSIVE DIAGNOSTIC SYSTEM FOR THE T800-APW-800 ENGINE
ANDREW R. BILODEAU and KENNETH S. COLLINGE (Textron Lycoming, Stratford, CT) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 393-399.
Copyright
An advanced engine-monitoring system (EMS) for the T800-APW-800 gas turbine engine has been developed as a comprehensive diagnostic system which monitors, diagnoses, and provides maintenance and repair instructions and mission data records. The EMS provides both flight and maintenance crew support with information on engine performance, condition, operational history, maintenance requirements, repair instructions, and logistic information. The system minimizes false diagnosis, reducing No Evidence of Failure returns to depot. In this paper, the EMS functions, its mode of operation, and logistics support are described. C.D.

A90-28183
FLIGHT TESTS OF ADAPTIVE FUEL CONTROL AND DECOUPLED ROTOR SPEED CONTROL SYSTEMS
STEPHEN W. KILLION (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 413-419.
(Contract DAAJ02-86-C-0013)
Copyright
Adaptive Fuel Controls (AFCs) and a Decoupled Rotor Speed Control System (DRSCS) have been successfully demonstrated on the BHTI 222/680 helicopter. Based on flight test demonstrations results, it is concluded that a full-authority digital electronic fuel control may be designed for a given helicopter/engine configuration to be successfully developed on the aircraft without requiring extensive engine test-cell support. The AFC reduces pilot workload and increases engine service life by providing cooler, more consistent engine starts under normal and extraordinary conditions. It also reduces pilot workload and enhances aircraft maneuverability through tighter rotor speed control and provides capability for improved fuel economy in cruise. The DRSCS reduces pilot workload by providing a positive physical cue prior to rotor red-line exceedance and automatically limiting rotor overspeed. C.D.

A90-28199
MISSION EFFECTIVENESS TESTING OF AN ADAPTIVE ELECTRONIC FUEL CONTROL ON AN S-76A
DAVID M. WALSH (Sikorsky Aircraft, West Palm Beach, FL) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 605-616.
Copyright
Flight tests of a digital electronic adaptive fuel control (AFC) were conducted on an S-76A helicopter, and the results are reported. Quantitative measurements of improvement due to the AFC were obtained for aircraft maneuver times, measured pilot workload, target tracking accuracy and pilot ratings. Assessments of target tracking accuracy and measured pilot workload were made, and a laser weapons simulator was used to obtain target tracking data for a variety of air-to-ground and air-to-air scenarios. Results from the targeting maneuvers showed that operation in adaptive control enhanced aircraft maneuverability and improved pilot confidence, leading to reduced target acquisition times and improved target tracking. Measured pilot workload was also noticeably reduced when operation was in adaptive control. C.D.

A90-28207
A SYNERGISTIC APPROACH TO LOGISTICS PLANNING AND ENGINE DESIGN
MARK HALL and KEVIN ROSS (LHTEC, Indianapolis, IN) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 737-742.
Copyright
A program to enhance maintainability of the T800-LHT-800 front-drive, free-turbine turboshaft engine, which has recently by chosen by the U.S. Army to power the advanced LHX helicopter,

is discussed. The establishment of a maintainability attitude and the promotion of increased awareness of maintainability goals in relevant personnel and organizations is addressed. The measurement and evaluation of progress in maintainability are considered. C.D.

A90-28272
MEAN AND TURBULENT VELOCITY MEASUREMENTS IN A TURBOJET EXHAUST
HANS J. SCHAEFER and ECKHART W. SOMMER (Saint-Louis, Institut Franco-Allemand de Recherches, France) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 206-214. refs
Copyright

Laser Doppler velocimeter measurements have been conducted in the round high-speed high-temperature jet exhausting from a small-scale turbojet propulsion engine (designed as a power unit for small aircraft). A survey of the jet flowfield at Mach numbers 0.46, 0.67, and 0.84 and a spectral analysis of the velocity fluctuations are presented. In good agreement with the results obtained in isothermal jets, the radial distributions of the mean and rms velocities can be approximated by universal profiles. The spectra of the fluctuations exhibit a pronounced narrow-band peak, providing evidence for the existence of coherent structures in the jet flow. I.E.

A90-28571* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ADVANCED TECHNOLOGY'S IMPACT ON COMPRESSOR DESIGN AND DEVELOPMENT - A PERSPECTIVE
CALVIN L. BALL (NASA, Lewis Research Center, Cleveland, OH) Cliff Garrett Turbomachinery Award Lectures, 6th, Anaheim, CA, Sept. 25, 1989. 18 p. Previously announced in STAR as N90-10891. refs
(SAE PAPER 292213; SAE SP-800) Copyright

A historical perspective of the impact of advanced technologies on compression system design and development for aircraft gas turbine applications is presented. A bright view of the future is projected in which further advancements in compression system technologies will be made. These advancements will have a significant impact on the ability to meet the ever-more-demanding requirements being imposed on the propulsion system for advanced aircraft. Examples are presented of advanced compression system concepts now being studied. The status and potential impact of transitioning from an empirically derived design system to a computationally oriented system are highlighted. A current NASA Lewis Research Center program to enhance this transitioning is described. Author

A90-29880
THE IN SERVICE MULTI-AXIAL-STRESS SITUATION IN AN UNCOOLED GAS TURBINE BLADE
A. FISCHERSWORRING, G. HELLENTHAL, and W. KOSCHEL (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany) IN: Advances in fatigue science and technology; Proceedings of the NATO Advanced Study Institute, Alvor, Portugal, Apr. 4-15, 1988. Dordrecht, Kluwer Academic Publishers, 1989, p. 947-959. refs
Copyright

The assessment of fatigue-creep life of hot engine components is continuously in demand, triggered by both economic and safety arguments. The life prediction of such components, either using conventional safe life design approaches or damage tolerant design concepts, requires the computation and evaluation of the stress-strain-temperature-time envelope corresponding to the operational sequences. For a typical jet engine operation the temperature and elastic stress-strain states for an uncooled turbine blade were calculated using finite elements. In order to cope and describe adequately the component behavior with the service multiaxial stress situation, primary attention is given to the description of multiaxiality and associated nonproportionality. The results are discussed in regard to multiaxial equivalent damage and nonproportional plasticity concepts. Author

A90-29904#
PREDICTION OF HEAT TRANSFER COEFFICIENT ON TURBINE BLADE PROFILES
DINGYI WU and SONGLING LIU (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 5, Jan. 1990, p. 21-25, 90. In Chinese, with abstract in English. refs

Several problems involved in the prediction of heat transfer coefficient on the turbine blade profiles without film cooling are studied for the purpose of improving the accuracy. These problems are: heat transfer in the vicinity of stagnation point, the location of boundary layer transition, heat transfer of transitional boundary layer, and the influence of free stream turbulence intensity. The Cebeci-Smith method is used to solve the boundary layer equations, obtaining a similar solution in the vicinity of stagnation point. STANS with some modifications is used to calculate heat transfer coefficient on the rest part of the blade surface. Transition origin and transition length are predicted by using the models suggested by Seyb (1972) and Dhawn et al. (1958), respectively. Author

A90-29906#
THE EFFECT OF SWIRLER ON SHORT REVERSAL-FLOW ANNULAR COMBUSTOR
YAN HONG (Nanhua Powerplant Research Institute, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 5, Jan. 1990, p. 29-31. In Chinese, with abstract in English.

A short reversal-flow annular combustor has been tested with three different flame liner heads. The gas parameters of the exit-section are detected by a turning measuring system, and data are processed on a PC-8001 microcomputer. Experimental results of efficiency, temperature field of exit-section, flame stabilization, and pressure loss are presented. The effect of a swirler on the short reversal-flow annular combustor is illustrated by comparison and analysis. The experimental study shows that the installation of a swirler on the flame liner head in a short reversal-flow annular combustor can improve the combustor performance. Author

A90-29908#
STUDY ON TRAVELLING WAVE VIBRATION OF BLADED DISKS IN TURBOMACHINERY
LITANG YAN (Beijing University of Aeronautics and Astronautics, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 5, Jan. 1990, p. 35-38. In Chinese, with abstract in English.

The exciting sources for axial vibration of disk, especially the new axial gas dynamic force induced by traveling waves and its properties, and influence on the vibration of disks are studied. It is shown that the traveling wave induces a new gasdynamic force which can damp out the forward traveling wave vibration and induces the self-excited vibration for the backward traveling wave vibration. The resonance and the self-excited stationary wave vibrations are generated during the critical speeds of the disk. An equation for calculating the instability of the stationary wave vibration of the disk is also given. Author

A90-29917#
A DESIGN OF A TWIN VARIABLE CONTROL SYSTEM FOR AERO-TURBOJET ENGINE
JIAZHENG ZHANG, KAI HUA, YINGQING GUO, and FANG LIU (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 5, Jan. 1990, p. 76-78. In Chinese, with abstract in English.

A dynamic model of a twin spool turbojet engine with two inputs and two outputs is proposed. With the aid of LQR theory, an optical regulator for a twin variable control system is designed, and approaches for processing some design problems are recommended. Finally, the control system designed in terms of optical method is simulated numerically. The results show that, in the condition of a state perturbation on the system, the transient performance of the system recovered to original state is more satisfactory, and the variation of control mediators is in allowable limits of the controllers. Author

A90-29918#
A NUMERICAL SOLUTION FOR INSTRUCTION TRACING PROBLEM
LINGUAN ZHANG (Wuxi Aeroengine Research Institute, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 5, Jan. 1990, p. 79-81. In Chinese, with abstract in English.

This paper describes a simple numerical solution for an instruction tracing problem in the engine multivariable control system. In this method the instruction tracing problem turns into the regulator problem to be solved only by simple algebraic transformation, and the optimal feedback control can be obtained with the matrix Riccati equation. Besides, a practical example is presented in which the method is applied to the simulation of an aeroengine control system. Author

A90-29919#
DIGITAL ELECTRONIC CONTROL FOR WJ6G4A ENGINE
FENGXIANG TAN and YOUBIN CHEN (Nanhua Powerplant Research Institute, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 5, Jan. 1990, p. 82-84. In Chinese, with abstract in English.

This paper deals with technical problems in developing a dual channel electronic control system JYZD-01 for a modified turboshaft aeroengine WJ6G4A which seraves as a powerplant of a locomotive. All performance tests and cyclic duration tests of the WJ6G4A engine burning kerosene and heavy fuel have been done under control of the developed system. The measured data meet the design requirements. Author

A90-29922
AEROTHERMOMECHANICAL DESIGN OF TURBINE-ENGINE COMBUSTION CHAMBERS [DIMENSIONNEMENT AERO THERMO MECANIQUE DES CHAMBRES DE COMBUSTION DE TURBOREACTEURS]
G. BAYLE-LABOURE (SNECMA, Moissy-Cramayel, France) Revue Francaise de Mecanique (ISSN 0373-6601), no. 4, 1989, p. 381-387. In French.
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Methodology used by Snecma to design, evaluate, and fabricate combustion chambers is presented. A dual-step approach is studied in which design techniques and calculation methods are developed. The combustion chamber is then designed using the tools derived during preliminary research; This approach includes aerodynamic, heat transfer, and mechanical design stages. It is shown that this approach successfully leads to rapid product development. The methodology may be also used for other engine parts particularly affected by heat and mechanical conditions. It is noted that any limitations to this design methodology may be attributed in principle to neglecting restrictions due to three-dimensional internal flow in the burner can. R.E.P.

A90-29946
MODELLING AND SIMULATION OF TURBOPROP ENGINE BEHAVIOUR
JAROSLAV DOLEZAL, ZDENEK SCHINDLER, JIRI FIDLER (Ceskoslovenska Akademie Ved, Ustav Teorie Informace a Automatizace, Prague, Czechoslovakia), and OLDRICH MATOUSEK (Vyzkumny a Zkusebni Letecky Ustav, Prague, Czechoslovakia) Acta Technica CSAV (ISSN 0001-7043), vol. 35, no. 1, 1990, p. 1-27. refs
Copyright

Based on dynamic and thermodynamic equations and experimentally given characteristics of each component, a computer-aided system for modeling and simulation of turbine engine behavior is developed. The steady-state regimes of the engine are described as a system of nonlinear algebraic equations and inequalities, which are treated as constraints in certain nonlinear mathematical programming problem for optimal selection of design parameters and operating conditions. The transition regime simulation is performed in analogical way as a solution of a system of nonlinear algebraic-differential equations. Author

A90-30699
THE EVOLUTION OF BUILT-IN TEST FOR AN ELECTRICAL POWER GENERATING SYSTEM (EPGS)
SANDRA J. DAILEY and WILLIAM F. CARPENTER (Sundstrand Corp., Advanced Technology Group, Rockford, IL) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 230-232.
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The authors review the history of the EPGS built-in test (BIT), types of BIT, the lessons learned from EPGS BIT evolution, and BIT effectiveness. While earlier fault isolation capabilities relied on analog-based built-in-test (BIT) systems, current designs now use microprocessor-based BIT systems or a combination of the two. It is noted that locations of readouts and types of codes/information play an important part in BIT utilization. I.E.

A90-30712
A STUDY OF A PROPULSION CONTROL SYSTEM FOR A VATOL AIRCRAFT (A DIRECT DESIGN SYNTHESIS APPLICATION)
LEO H. MCWILLIAMS, ELIZABETH A. RAVEN (Allied-Signal Aerospace Co., Bendix Engine Controls Div., South Bend, IN), and PATRICK M. SAIN (Notre Dame, University, IN) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 356-363. refs
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The authors present an application of the direct design synthesis (DDS) methodology to the study of the design of a propulsion control system for a vertical attitude takeoff and landing aircraft (VATOL) computer simulation. This application is particularly relevent to modern integrated control systems design methodologies due to the requirements of modern propulsion systems to provide stability augmentation. This requirement necessitates tight coupling between the flight and propulsion control system. A modified version of the Vought SF-121 VATOL aircraft simulation and an F100 engine core was selected. The integrated system was constrained to operate at low-altitude conditions for this analysis. The results of the simulations show that the DDS methodology has merit for consideration in integrated control design applications. The multivariable nature of the methodology allowed the control of engine variables necessary for proper engine operation as well as the control of engine variables that coupled with other subsystems in the integrated system. The requirements for the transient performance on engine thrust generated by the flight control system and the requirements on selected internal engine variables were directly translated into performance parameters. Details of the design and integration were provided along with simulations that showed total system performance during a switch of flight control system modes. I.E.

A90-30811
AN OPTICALLY INTERFACED PROPULSION MANAGEMENT SYSTEM APPLIED TO A COMMERCIAL TRANSPORT AIRCRAFT
CURT W. MAINARD (Douglas Aircraft Co., Long Beach, CA) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 4. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 1986-1990.
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A fly-by-light propulsion management system to transport aircraft under development is described. The system includes an optically interfaced full-authority digital electronic control evaluation system, optical angular position sensors used to sense throttle position, a set of four optical position switches, and an optical ARINC 629 data link. These components, together with a mounting fixture for the sensors, optical cables and connectors, and a data-management unit, are being devleoped for design into an optical propulsion management system. This system is scheduled to be flight-evaluated on the NASA LaRC 737 ATOPS research aircraft. The objectives of this program are to evaluate the feasibility of using fiber-optic links across the engine/airframe interface and to encourage vendor participation in order to establish a state of vendor technology readiness for the early 1990s. I.E.

A90-30817
F-111/TF30 ENGINE MONITORING SYSTEM - A FUSION OF PAST, PRESENT, AND FUTURE TECHNOLOGY
RICHARD D. SOMERS (Southwest Research Institute, San Antonio, TX) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 4. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 2062-2069.
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The extension of present-day engine-monitoring technology to older aircraft and demonstration of future diagnostic technologies are discussed. A development program for F-111/TF30 engine monitoring is described. The system design utilizes standard parts and technology insertion upgrades such as MIL-STD-1750A computer designs for existing complex devices. A design agent approach was used to realize the logistics goal of providing an Air-Force-owned design which could be purchased from multiple sources. An internal research and development program to investigate neural-network applications to expert-system diagnostics is described. A competitive associative network was used to implement the troubleshooting diagnostics for TF30 engine start problems and to examine its application potential. I.E.

N90-18396# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials.
AGARD/SMP REVIEW: DAMAGE TOLERANCE FOR ENGINE STRUCTURES. 2: DEFECTS AND QUANTITATIVE MATERIALS BEHAVIOUR
Aug. 1989 105 p In ENGLISH and FRENCH Meeting held in Mierlo, Netherlands, 2-7 Oct. 1988
(AGARD-R-769; ISBN-92-835-0518-2) Copyright Avail: NTIS HC A06/MF A01; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Most current military and all civil engines are operated under safe life procedures for their critical components. Experience has shown that this philosophy presented two drawbacks: the move towards designs allowing higher operational stresses, and the use of advanced high strength alloys make it likely that a disc burst could happen (followed by a rapid crack growth) well before the statistically-based safe life was achieved; and it is potentially wasteful of expensive components, since it was estimated that over 80 percent of engine discs have ten or more low cycle fatigue lives remaining when discarded under safe life rules. Damage tolerance being an alternative life philosophy, it was therefore decided to conduct a series of four workshops addressing the areas critical to damage tolerance design of engine parts.

N90-18402# Pratt and Whitney Aircraft of Canada Ltd., Longueuil (Quebec).
REVIEW OF MODELLING METHODS TO TAKE ACCOUNT OF MATERIAL STRUCTURE AND DEFECTS
R. N. TADROS and K. REZAI *In* AGARD, AGARD/SMP Review: Damage Tolerance for Engine Structures. 2: Defects and Quantitative Materials Behaviour 15 p Aug. 1989
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Among the many requirements for the design of gas turbine engine components, understanding the behavior of these components and the alloys used to make them is fundamental in order to ensure structural integrity and safe operation of the engines. The conventional Safe Life Approach is discussed together with an overview of crack growth modeling used at Pratt and Whitney Canada. The intention is not to compare the two approaches, but rather to highlight their applications and required improvement for the design and production of next generation gas turbine engines. Author

N90-18404# Centre d'Essais Aeronautique Toulouse (France). Groupe Materiaux et Technologies.
THE NEED FOR A COMMON APPROACH WITHIN AGARD [LE BESOIN D'ACTIONS CONCERTEES AU SEIN DE L'AGARD]
TH. PARDESSUS *In* AGARD, AGARD/SMP Review: Damage Tolerance for Engine Structures. 2: Defects and Quantitative Materials Behaviour 5 p Aug. 1989 In FRENCH
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The need for agreement within AGARD on what constitutes a fully integrated material specification for damage tolerance is addressed. Suggestions are made regarding a test procedure that would help define more precisely defect sizes and populations. Test methods, the role of materials behavior modeling, component life, and the notion of usable strength are discussed.
Transl. by M.G.

N90-18405# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Propulsion and Energetics Panel.
UNSTEADY AERODYNAMIC PHENOMENA IN TURBOMACHINES
Feb. 1990 325 p In ENGLISH and FRENCH Meeting held in Luxembourg, 28-30 Aug. 1989
(AGARD-CP-468; ISBN-92-835-0543-3) Copyright Avail: NTIS HC A14/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The Specialists' Meeting was arranged in the following sessions: Flutter or oscillating cascades; wakes or complete stage; transonic and supersonic unsteady phenomena; and experimental studies and instrumentation problems. While around isolated airfoils many results on unsteady aerodynamic phenomena are available; reliable experimental data for unsteady turbomachinery flows were still missing. Therefore a forum was offered to experts to discuss the degree of advancements in this field. It was found that computational fluid dynamics with large numerical codes will be more and more developed and offer a useful tool for designers to improve their products. The experimental work for code verification is lagging somewhat behind.

N90-18406# Motoren- und Turbinen-Union Muenchen G.m.b.H. (Germany, F.R.).
A COMPARISON OF FLUTTER CALCULATIONS BASED ON EIGENVALUE AND ENERGY METHOD
A. KLOSE and K. HEINIG *In* AGARD, Unsteady Aerodynamic Phenomena in Turbomachines 9 p Feb. 1990
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The effect of unsteady aerodynamic loads on the natural modes and frequencies of unshrouded blades of axial flow turbomachinery is investigated. It is shown that significant shifts in eigenfrequencies and aerodynamic coupling between different modes do no occur for blades with a large mass ratio. Even for compressor and turbine bladings of recent design, it is generally possible to neglect the effect of unsteady aerodynamic forces on the vibration characteristics. Therefore, the energy method is applicable for the theoretical flutter investigation of these machines. However, for future light-weight designs, e.g., hollow fan blades or blades made of fiber-reinforced plastics, the effects of unsteady airloads on the vibration characteristics will be larger. In these cases, the eigenvalue method will have to be employed for flutter prediction as well as for the calculation of eigen frequencies and natural modes. Author

N90-18407# Technische Hochschule, Aachen (Germany, F.R.). Inst. fuer Strahlantriebe und Turboarbeitsmaschinen.
NUMERICAL INVESTIGATION OF UNSTEADY FLOW IN OSCILLATING TURBINE AND COMPRESSOR CASCADES
H. P. KAU and H. E. GALLUS *In* AGARD, Unsteady Aerodynamic Phenomena in Turbomachines 11 p Feb. 1990
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A method of computing the unsteady two dimensional, inviscid subsonic flow through an oscillating compressor and turbine cascades is presented. The nonlinear Euler equations in conservative law form are solved taking into account the time dependent geometry. For interior points MacCormack's explicit predictor-corrector scheme is used. Boundary conditions are formulated by characteristics methods. A comparison of computational results and experimental data is given. A study is performed showing the influence of important aerodynamic and geometric parameters on the time-dependent forces and moments. Author

N90-18408# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
UNSTEADY VISCOUS CALCULATION METHOD FOR CASCADES WITH LEADING EDGE INDUCED SEPARATION
M. GAZAIX, P. GIRODROUX-LAVIGNE, and J. C. LEBALLEUR *In* AGARD, Unsteady Aerodynamic Phenomena in Turbomachines 13 p Feb. 1990 In FRENCH; ENGLISH summary Sponsored by SNECMA, France
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The recent progress in viscous-inviscid interaction methods for computation of unsteady separated flows over airfoils, in forced oscillations, as well as, in the buffet regime, makes it possible to develop a numerical method for computations of unsteady flows over airfoils and cascades where the flow separation or stall is induced by sharp leading-edges. The aptitude of the method to describe the leading-edge separation in unsteady flow gives some hope for the prediction of subsonic flutter in cascades. The method solves unsteady thin-layer integral viscous equations, in defect-formulation, including two transport equations for turbulence. The equations are closed by turbulent mean velocity profiles which are modeled and discretized along the normal. The viscous method is strongly coupled time-consistently, by the so-called semi-implicit numerical technique, with a pseudo-inviscid solver based on potential small perturbation approximations. The numerical technique is able to enforce the separation at a sharp leading-edge. A viscous calculation method for airfoils is first shown to predict the leading-edge separation over a sharp flat plate at incidence, and over isolated compressor blades. Steady and unsteady computations are presented, and compared with experimental results. A numerical method for internal flows, including conditions of periodicity in space for steady flows, and in space-time for unsteady flows, is secondly obtained to compute separated flows in a cascade configuration. Steady and preliminary unsteady results are shown. Author

N90-18411# Pennsylvania State Univ., University Park. Applied Research Lab.
DESIGN GUIDANCE TO MINIMIZE UNSTEADY FORCES IN TURBOMACHINES
R. E. HENDERSON and J. H. HORLOCK (Open Univ., Milton, England) *In* AGARD, Unsteady Aerodynamic Phenomena in Turbomachines 12 p Feb. 1990
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A method is discussed for the development of design charts which provide guidance in the selection of a stage design loading coefficient and flow coefficient which minimizes the generation of unsteady forces in a blade row due to its interaction with the wakes of an unstream blade row. Two configurations are discussed, the forces on a rotor operating in the wakes of an inlet stator or guide vane and the forces on a stator downstream of a rotor. An example demonstrating the generation of a design chart for the first configuration is presented. Author

N90-18412# Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, Moissy-Cramayel (France).
AERODYNAMIC STUDY ON FORCED VIBRATIONS ON STATOR ROWS OF AXIAL COMPRESSORS
H. JOUBERT and V. RONCHETTI *In* AGARD, Unsteady Aerodynamic Phenomena in Turbomachines 11 p Feb. 1990 In FRENCH; ENGLISH summary
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Stator vane rows of axial compressors are dependent on fluctuations induced by the wakes of the previous upstream blades row. The unsteady flow resulting from this rotor-stator interaction creates aerodynamic exitations which may initiate vibrating fatique stress in the vanes and disable the engine. In order to take into account these phenomena, a numerical model based on two dimensional Euler equations was studied. The upstream condition fluctuations come from correlations established from wake experimental testing. The unsteady pressures calculated from the model are afterwards introduced in a mechanical model which estimate the dynamic stress inside the vane-structure. The variation of aerodynamic values such as pressure loss in the blade and geometric one such as rotor-stator spacing or fluctuation of the number of the vanes or stator were studied; therefore, as soon as the aeromechanic design charts of the compressor are designed, some sizing choice could be made to minimize the stress on the blade assembly. Author

N90-18413# Motoren- und Turbinen-Union Muenchen G.m.b.H. (Germany, F.R.).
UNSTEADY BLADE LOADS DUE TO WAKE INFLUENCE
S. SERVATY and H. E. GALLUS (Technische Hochschule, Aachen, Germany, F.R.) in AGARD, Unsteady Aerodynamic Phenomena in Turbomachines 12 p Feb. 1990
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An algorithm for calculating unsteady blade forces and moments due to incoming wakes is presented. The mathematical model describes the unsteady two-dimensional flow through compressor and turbine cascades. Only inviscid transport of the wake is considered. The nonlinear Euler equations in conservative law form are solved by a combined method. MacCormack's explicit predictor-corrector scheme is used at interior points. Time-dependent boundary conditions are formulated by means of a characteristics method. Fundamental studies and several test cases are presented to check the algorithm. Comparisons with experimental results are discussed as well. Author

N90-18416*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
NUMERICAL PREDICTION OF AXIAL TURBINE STAGE AERODYNAMICS
H. V. MCCONNAUGHEY and L. W. GRIFFIN *In* AGARD, Unsteady Aerodynamic Phenomena in Turbomachines 15 p Feb. 1990
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A preliminary assessment is made of two NASA-developed unsteady turbine stage computer codes. The methodology and previous partial validation of the codes are briefly outlined. Application of these codes to a Space Shuttle main engine turbine for two sets of operating conditions is then described. Steady and unsteady, two and three-dimensional results are presented, compared, and discussed. These results include time-mean and instantaneous airfoil pressure distributions and pressure fluctuations, streamlines on the airfoil surfaces and endwalls, and relative total pressure contours at different axial locations in the rotor passage. Although not available at the time of this writing, experimental data for one of the operating conditions simulated is forthcoming and will be used to assess the accuracy of the unsteady, as well as, the steady predictions presented. Issues related to code usage and resource requirements of the two codes are also discussed. Author

N90-18418# Rolls-Royce Ltd., Derby (England).
DEVELOPMENT OF A MASS AVERAGING TEMPERATURE PROBE
S. C. COOK and R. L. ELDER (Cranfield Inst. of Tech., Bedford, England) *In* AGARD, Unsteady Aerodynamic Phenomena in Turbomachines 14 p Feb. 1990 Sponsored by Ministry of Defence, England
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In research and development testing of axial flow fan and compressor rigs, the overall performance can normally be determined to a satisfactory accuracy using conventional methods. It is known, however, that conventional slow response instrumentation does not respond correctly to the highly unsteady flows encountered between blade rows in high speed turbomachines. Consequently measurements made in these areas, in an attempt to split the loss of the machine, typically lead to gross errors in stage, or blade element, performance assessments. A slow response temperature sensor, the Reverse-Kiel probe, was created by employing a judicious shield design in an attempt to allow the probe to indicate the correct mass-weighted temperature of such unsteady turbomachinery flows. The mass-weighted Reverse-Kiel temperature probe was developed using some simple arguments supported by flow visualization and computational modeling. The predicted best probe designs were evaluated and confirmed on the purposed blade-wake rig. The optimum probe was built as a standard rig probe and now is undergoing preliminary test studies. Author

N90-18421# Wien Univ. (Austria). Inst. for Stroemungslehre und Waermeuebertragung.
ASYMPTOTIC ANALYSIS OF TRANSONIC FLOW THROUGH OSCILLATING CASCADES
FRANZ KOLLER and ALFRED KLUWICK *In* AGARD, Unsteady Aerodynamic Phenomena in Turbomachines 10 p Feb. 1990
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The plane flow of a perfect gas through an oscillating cascade at a Mach number close to one is analyzed using matched asymptotic expansions. In the case of steady flow the field quantities in the regions between airfoils are governed by the equations for one-dimensional flow in a first approximation if thickness, camber, and angle of incidence of the blades are small. Moreover, for a particular range of these parameters the velocity disturbances satisfy linear equations ahead of and behind the cascade. The same property is shown to hold in the case of unsteady flow provided the reduced frequency and the amplitudes of the oscillations are small compared to unity. Furthermore, the effects of the sizes of the various parameters on the flow field are discussed. Surface pressures are calculated for cascades of flat plate and double circular arc airfoils. Author

N90-18422# Technische Hochschule, Aachen (Germany, F.R.). Inst. fuer Strahlantriebe und Turboarbeitsmaschinen.
EXPERIMENTS ON THE UNSTEADY FLOW IN A SUPERSONIC COMPRESSOR STAGE
W. ELMENDORF, G. K. KAUKE, and K. D. BROICHHAUSEN (Motoren- und Turbinen-Union Muenchen G.m.b.H., Germany, F.R.) *In* AGARD, Unsteady Aerodynamic Phenomena in Turbomachines 13 p Feb. 1990
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The intensity of unsteadiness in compressors strongly depends on the flow velocity and the overall pressure ratio. Thus investigations of the unsteady effects in the case of supersonic flow are of great importance with regard to performance and reliability. For that purpose the unsteady flow in a supersonic compressor stage was studied in a series of experiments. A review on the specially developed measuring techniques including flow visualization and the design of miniaturized semiconductor probes is given. The main feature of unsteady supersonic flow in the compressor are discussed by means of characteristic experimental results. Author

N90-18423# Cambridge Univ. (England). Dept. of Engineering.
MODELLING UNSTEADY TRANSITION AND ITS EFFECTS ON PROFILE LOSS
H. P. HODSON *In* AGARD, Unsteady Aerodynamic Phenomena in Turbomachines 15 p Feb. 1990
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The effects of wake interactions on the transition processes of turbomachinery blade boundary layers are considered. A simple model of unsteady transition is proposed which is then used to identify a relationship between a new reduced frequency parameter and the profile loss of a blade row which is subjected to unsteady inflow. The value of this parameter is also used to identify the nature of the boundary layer development on the blade surface. The influence of other parameters on the transition process is also discussed. The model is then extended to deal with the more general case. The validity of the model is demonstrated by a comparison with a correlation of the effects of wake-generated unsteadiness on profile loss which was originally proposed by Speidel. The effects of unsteady inflow on four idealized turbine blades are considered. Author

N90-18425# Technische Hochschule, Aachen (Germany, F.R.). Inst. fuer Strahlantriebe und Turboarbeitsmaschinen.
EXPERIMENTAL INVESTIGATION OF THE INFLUENCE OF ROTOR WAKES ON THE DEVELOPMENT OF THE PROFILE BOUNDARY LAYER AND THE PERFORMANCE OF AN ANNULAR COMPRESSOR CASCADE
H. D. SCHULZ and H. E. GALLUS *In* AGARD, Unsteady Aerodynamic Phenomena in Turbomachines 15 p Feb. 1990
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The development of the profile boundary layers, particularly the loci of transition and separation, largely depend on the turbulence level of the free-stream and the wake flow effects. For comparison, a detailed survey of the profile boundary layers in an annular compressor cascade was carried out first at a steady, uniform incoming flow and secondly with a rotor upstream. The rotor incorporates cylindrical spokes causing periodic wakes and thus a higher overall turbulence level of the flow. Its impact on the profile boundary layer history and the performance of the compressor cascade will be discussed. Author

N90-18428# Wright Research Development Center, Wright-Patterson AFB, OH. Turbine Engine Div.
COMPRESSOR PERFORMANCE TESTS IN THE COMPRESSOR RESEARCH FACILITY
F. R. OSTDIEK, W. W. COPENHAVER, and D. C. RABE *In* AGARD, Unsteady Aerodynamic Phenomena in Turbomachines 16 p Feb. 1990
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An advanced compressor test facility, the Compressor Research Facility (CRF) was established. The CRF is designed for exploration of steady-state and transient behavior of full-scale, multistage gas turbine engine fans, and compressors. Since construction and check-out of the facility, the CRF test team has completed its first five years of testing with a variety of test articles. Customers besides the Air Force have included other Government agencies and industry. Turbine engine technology is changing rapidly with new mission demands on the engine resulting in new aerodynamic, stability, and performance demands on each of its components. The role of the CRF in meeting the challenges inherent in such a rapidly changing field is described. The facility characteristics are described along with a description of the changes, modifications, and enhancements made to the facility in its short history. Several examples of tests performed in the CRF (both steady-state and transient) are used to demonstrate the impact of the CRF results on engine development. Finally, the plans for further facility modifications and enhancement are given. This affords a preview of the impact which this and other test facilities will have on turbine engine technology. Author

N90-18429# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Mechanical Engineering.
STALL AND RECOVERY IN MULTISTAGE AXIAL FLOW COMPRESSORS
WALTER F. OBRIEN and KEITH M. BOYER (Wright Research Development Center, Wright-Patterson AFB, OH.) *In* AGARD, Unsteady Aerodynamic Phenomena in Turbomachines 11 p Feb. 1990 Sponsored by AFOSR, Washington, DC
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At low flows relative to the design point, multistage axial flow compressors may enter a globally-stable operational state involving rotating stall within the blade passages. For continued operation in a turbine engine, recovery of the compressor to normal operation is required. Operation in rotating stall is generally characterized by recovery hysteresis; that is, to produce recovery, compressor flow must be allowed to increase substantially beyond the initial flow level observed with rotating stall. In turbine engine applications, it is desirable to reduce compressor recovery hysteresis to a minimum. Stage flow behavior and stage matching at low flows are shown to have a major influence on recovery behavior. Conclusions are supported through the use of an analytical model recently validated with experimental data from tests of a multistage compressor in the Compressor Research Facility at Wright-Patterson Air Force Base. Author

N90-18430# Army Aviation Engineering Flight Activity, Edwards AFB, CA.
PRELIMINARY AIRWORTHINESS EVALUATION OF THE WOODWARD HYDROMECHANICAL UNIT INSTALLED ON T700-GE-700 ENGINES IN THE UH-60A HELICOPTER Final Report, 14 May - 14 Jun. 1989
JOSEPH L. PIOTROWSKI, CHRISTOPHER J. YOUNG, THOMAS P. WALSH, and JULIE SANDMAN Aug. 1989 56 p Sponsored by Army Aviation Systems Command, Saint Louis, MO
(AD-A216751; AEFA-89-14) Avail: NTIS HC A04/MF A01
CSCL 01/3

The U.S. Army Aviation Engineering Flight Activity conducted a Prelimiary Airworthiness Evaluation of the Woodward Hydromechanical Unit (HMU) installed on T700-GE-700 engines in the UH-60A helicopter from 14 May 1989 to 14 June 1989. The evaluation was conducted at Edwards AFB, California (elevation 2302 feet) and Coyote Flat, California (elevation 9980 feet) on aircraft S/N 88-26015. The evaluation consisted of eleven flights for a total of 15.5 productive flight hours. Performance of the Woodward HMU and the Hamilton Standard HMU, presently used on T700-GE-700 engines, was similar. The poor engine/rotor transient droop characteristics, as noted in previous testing, remain a shortcoming regardless of the HMU installed. Operation of T700-GE-700 engines with Woodard HMUs installed is satisfactory. GRA

N90-19232# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Propulsion and Energetics Panel.
THE UNIFORM ENGINE TEST PROGRAMME
PETER F. ASHWOOD and JAMES J. MITCHELL, ed. Feb. 1990 147 p
(AGARD-AR-248; ISBN-92-835-0501-8) Copyright Avail: NTIS HC A07/MF A01; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The results of the Propulsion and Energetics Panel Working Group 15 are summarized. The Group was in operation 1980 to 1987 and performed test runs of two J57 turbojet engines at eight different facilities for ground-level and altitude tests, in five different nations. At two facilities the tests were repeated in order to review a possible deterioration of the engines. The test rig accompanied the engines to the test facilities. The tests were performed observing a carefully composed General Test Plan, being the same for all facilities. Each facility used its own data asquisition and processing system. Author

N90-19233# Ballistic Research Labs., Aberdeen Proving Ground, MD.
EXTERNAL FLOW COMPUTATIONS FOR A FINNED 60MM RAMJET IN STEADY SUPERSONIC FLIGHT Memorandum Report
BERNARD J. GUIDOS Dec. 1989 50 p
(Contract DA PROJ. 1L1-62618-AH-80)
(AD-A216998; BRL-MR-3801) Avail: NTIS HC A03/MF A01
CSCL 16/2

The U.S. Army Ballistic Research Laboratory (BRL) has participated in the development of the launch and flight technologies for a family of solid fuel ramjet (SFRU) projectiles. The ramjet is a tubular projectile which utilizes air ingested through the inlet to burn the solid fuel. When the combustion process ceases, the projectile becomes a high drag configuration. Several designs have been developed as potential tank gun training rounds (TGTR) for kinetic energy (KE) penetrators. This report documents a computational fluid dynamics study of the external aerodynamics of a finned 60mm solid-fuel ramjet in steady, supersonic, atmospheric flight. The main objective is to compute the external contribution to the pitch-plane aerodynamics using established in-house capabilities. Two space-marching finite-difference procedures are used to compute the external flow fields. Viscous flow results are generated using a thin-layer, parabolized Navier-Stokes technique; inviscid results are generated using an Euler solver. Results are shown for three configurations: body-alone, body with original fins, and body with extended fins. The influence of initial marching conditions on the modeling of an inlet configuration is examined. A generalized scaling law is introduced which may improve the accuracy of future external space-marching flow computations for ramjets. GRA

N90-19235# Technische Hochschule, Aachen (Germany, F.R.). Inst. fuer Strahlantriebe und Turboarbeitsmaschinen.
INFLUENCE OF FRICTION AND SEPARATION PHENOMENA ON THE DYNAMIC BLADE LOADING OF TRANSONIC TURBINE CASCADES [EINFLUSS VON REIBUNGS- UND ABLOESEVORGAENGEN AUF DIE DYNAMISCHE SCHAUFELBELASTUNG VON TRANSSONISCHEN TURBINENGITTERN]
H. E. GALLUS and J. HENNE Nov. 1988 163 p In GERMAN Sponsored by Wissenschaftsminister des Landes Nordrhein-Westfalen
(MITT-88-04; ETN-90-95324) Avail: NTIS HC A08/MF A01

The steady and unsteady flow in a transonic, plane turbine cascade with rigid blades as well as blades capable of vibration were investigated. The emphasis was on the behavior of the boundary layers and their interaction with compressional shocks with a view to an aerodynamic vibrational excitation of the blades. The experiments show that a careful shielding of the flow against unsteady perturbations is required for the measurement of unsteady cascade flow effects. The steady, transonic flow was calculated using a time marching method. The measurements of the unsteady flow show a largely stable shock-boundary-layer configuration. The amplitude variations of the compressional shocks is not substantially affected by the vibration capability of the blades. ESA

N90-19237# Massachusetts Inst. of Tech., Cambridge. Gas Turbine Lab.
EXPERIMENTAL AND THEORETICAL INVESTIGATIONS OF FLOWFIELDS AND HEAT TRANSFER IN MODERN GAS TURBINES Final Summary Report, 1 Jan. 1981 - 31 Mar. 1987
A. H. EPSTEIN, M. B. GILES, G. R. GUENETTE, and W. T. THOMPKINS, JR. Jan. 1990 35 p
(Contract N00014-81-K-0024)
(AD-A217663) Avail: NTIS HC A03/MF A01 CSCL 20/4

Aerodynamics and heat transfer of high pressure turbines were studied computationally and experimentally. Two- and three-dimensional steady, and two-dimensional unsteady viscous codes were written. An 0.3 second duration, full rotating stage, test rig was built and instrumented to yield both steady state and time-resolved data. The computational fluid dynamic (CFD) solution and experimental data were in good agreement. The rotating rig data resembled that from cascades rather than full scale engines. GRA

N90-19421*# Alabama Univ., Huntsville. Dept. of Aerospace Engineering.
THE INFLUENCE OF A WALL FUNCTION ON TURBINE BLADE HEAT TRANSFER PREDICTION
KEVIN W. WHITAKER *In its* Research Reports: 1989 NASA/ASEE Summer Faculty Fellowship Program 21 p Dec. 1989
(Contract NGT-01-008-021)
Avail: NTIS HC A99/MF E06 CSCL 21/5

The second phase of a continuing investigation to improve the prediction of turbine blade heat transfer coefficients was completed. The present study specifically investigated how a numeric wall function in the turbulence model of a two-dimensional boundary layer code, STAN5, affected heat transfer prediction capabilities. Several sources of inaccuracy in the wall function were identified and then corrected or improved. Heat transfer coefficient predictions were then obtained using each one of the modifications to determine its effect. Results indicated that the modifications made to the wall function can significantly affect the prediction of heat transfer coefficients on turbine blades. The improvement in accuracy due the modifications is still inconclusive and is still being investigated. Author

08

AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

A90-28007#
A PRACTICAL FLIGHT PATH FOR MICROWAVE-POWERED AIRPLANES
TAKESHI ITO (National Aerospace Laboratory, Tokyo, Japan) Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811), vol. 32, Feb. 1990, p. 228-231.

Although some types of closed flight paths have been proposed for microwave-powered aircraft, they have unfavorable features from a viewpoint of aircraft designers, especially under the strong wind conditions. Here, by defining the time variation of the air-speed vector, a well-behaved practical periodic flight path is deduced. Author

A90-28157
APPLICATION OF HIGHER HARMONIC CONTROL (HHC) TO ROTORS OPERATING AT HIGH SPEED AND MANEUVERING FLIGHT
KHANH NGUYEN and INDERJIT CHOPRA (Maryland, University, College Park) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 81-96. refs
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An advanced higher harmonic control (HHC) analysis is used to investigate the effects of HHC on rotors operating at high forward speeds and thrust levels, where the effects of dynamic stall and compressibility of the airflow may be substantial. The performance of HHC is evaluated in terms of the vibration reduction level, blade and control system fatigue loads, rotor performance, and power requirement of HHC servoactuators. For a rotor operating near or outside the flight boundary, the analytical results show that HHC used to suppress helicopter vibration can promote stall on the rotor disk. Results of sensitivity studies for a rotor operating at the level-flight boundary shows that blade torsion stiffness, offset of blade center-of-mass from the elastic axis, and offset of elastic axis from blade quarter-chord all have large effects on the actuator power requirement for an HHC system, whereas the flap and lag vibration characteristics have moderate effects. C.D.

A90-28200
THEORETICAL AND EXPERIMENTAL CORRELATION OF HELICOPTER AEROMECHANICS IN HOVER
S. S. HOUSTON and P. C. TARTTELIN (Royal Aerospace Establishment, Flight Dynamics Div., Bedford, England) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 617-639. refs
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This paper describes the development of an appropriate level of helicopter mathematical modeling for flight mechanics, handling, and control law design work, together with elements of a validation toolkit and data base. The focus for the modeling effort is a coupled, three-degrees-of-freedom body/coning/inflow representation of a helicopter in the hover flight conditions. The data analysis involves identification of equivalent system models using transfer function matching and the derivation of incidence and inflow from surface pressure and strain measurements. It is concluded that simplicity is generally not a barrier to fidelity, even in comprehensive high-bandwidth models. However, approximation and empiricisms need to be understood in the context of real behavior. C.D.

A90-28201* Massachusetts Inst. of Tech., Cambridge.
ACTIVE CONTROL OF GUST- AND INTERFERENCE-INDUCED VIBRATION OF TILT-ROTOR AIRCRAFT
NORMAN D. HAM, NORMAN M. WERELEY (MIT, Cambridge, MA), and KARL D. VON ELLENRIEDER IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 641-653. refs
(Contract NCC2-447)
Copyright

An active control system to suppress the response of the blade bending modes of a tilt-rotor aircraft to axial gusts and wing/rotor interference is described. The use of blade-mounted accelerometers as sensors is shown to permit the measurement and control of tilt-rotor blade modal responses and their associated vibratory loads directly. The feedback of modal acceleration, in addition to modal rate and displacement, is demonstrated to provide a control phase lead, in comparison with feedback of modal rate and displacement only, which makes higher system gains achievable. Author

A90-28202* Princeton Univ., NJ.
HELICOPTER FLIGHT CONTROL SYSTEM DESIGN AND EVALUATION FOR NOE OPERATIONS USING CONTROLLER INVERSION TECHNIQUES
ROBERT M. MCKILLIP, JR. and TODD A. PERRI (Princeton University, NJ) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 669-679. refs
(Contract NAG2-244)
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A flight control system design technique is described that allows rapid evaluation of candidate control laws using computer simulated trajectories. The two-step technique first computes the optimum trajectory for the basic aircraft, and then reconstructs the pilot's control displacements necessary to fly this trajectory, given a particular control system architecture. Since the flight control system itself does not add to the acceleration potential of the helicopter, one may evaluate several proposed control laws in terms of the resulting stick inputs for the same maneuver. The method is illustrated through application to implicit and explicit model-following control laws designed for a battlefield helicopter with and without an auxiliary propulsor. It is shown that the technique is a valuable aid for selection of promising control laws for further simulator studies and flight investigations. Author

A90-28204
CONTROL SENSITIVITY, BANDWIDTH AND DISTURBANCE REJECTION CONCERNS FOR ADVANCED ROTORCRAFT
STEWART W. BAILLIE and J. MURRAY MORGAN (National Aeronautical Establishment, Ottawa, Canada) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 693-702. Research supported by DND. refs
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A series of in-flight evaluations studying the effects of the variation in control response bandwidth, control sensitivity and disturbance rejection capability on the handling qualities of rotorcraft was carried out on the NAE Bell 205 Airborne Simulator. This paper presents an overview of this activity and will present preliminary results from the first phase of the experiment which dealt variations in roll axis characteristics. This paper also contains a review of the concept of disturbance rejection and a discussion regarding the measurement and documentation of such a characteristic. Author

A90-28216* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
RSRA/X-WING FLIGHT CONTROL SYSTEM DEVELOPMENT - LESSONS LEARNED
LLOYD D. CORLISS (NASA, Ames Research Center, Moffett Field, CA), WILLIAM R. DUNN (Southern Colorado, University, Pueblo, CA), and MICHAEL A. MORRISON IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 861-877. refs
(Contract NCC2-276)
Copyright
The X-Wing, in concept, marries the efficiencies of a helicopter and fixed wing aircraft through the use of a four-bladed wing/rotor that can be rotated or stopped in flight. The RSRA/X-Wing flight test program was a technology demonstration of this concept which, after three successful flights, was discontinued in late 1987. In spite of many technical challenges in this program, such as the use of circulation control, the fabrication of a large all-composite rotor, the development of an advanced, quadruplex digital flight control system, and the need for higher harmonic control, no major technical problems had been encountered at the time of the stop-work order. This paper addresses the issues of flight control system development and focuses on lessons learned. As with other such programs, software development was the most consuming issue. Other subjects of discussion include the problems of balancing program goals with technical goals, software- and hard-ware-related problems, safety issues, and system testing. Author

A90-28220
OPST1 - AN OPTICAL YAW CONTROL SYSTEM FOR HIGH PERFORMANCE HELICOPTERS
HERBERT KOENIG, MICHAEL STOCK, and SIEGFRIED ZELLER (MBB GmbH, Ottobrunn, Federal Republic of Germany) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 901-908.
Copyright
The OPST1 (digital optical control system, phase one) program comprises a digital helicopter yaw control system with all-optical signal transfer. It is the basis of a development program to investigate the feasibility and cost effectiveness of the application of the fly-by-light technology to future helicopters. In this paper, the status and application of this new technology are described. The system architecture, subsystems, helicopter installation, and flight testing conducted with a Bo 105 demonstrator helicopter are examined. C.D.

A90-28225
LINEAR CONTROL ISSUES IN THE HIGHER HARMONIC CONTROL OF HELICOPTER VIBRATIONS
STEVEN R. HALL and NORMAN M. WERELEY (MIT, Cambridge, MA) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 955-971. refs
Copyright
Classical linear control theory is used to develop a framework in which the performance of active vibration control algorithms can be evaluated in terms of compensator structure, closed loop vibration levels, and sensitivity to modeling errors due to changing flight conditions. This framework leads to the interpretation of current vibration control algorithms as classical narrow band disturbance rejection problems. Moreover, current HHC algorithms are quite robust with respect to errors in the T matrix, so that real time adaptation of the T matrix is probably not crucial to satisfactory performance. Author

A90-28227
STABILITY OF HINGELESS ROTORS IN HOVER USING THREE-DIMENSIONAL UNSTEADY AERODYNAMICS
DEWEY H. HODGES, OH JOON KWON, and LAKSHMI N. SANKAR (Georgia Institute of Technology, Atlanta) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 989-998. refs
(Contract DAAG29-82-K-0094; DAAL03-88-C-0003)
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The linear stability of a hingeless rotor in the hovering flight condition is determined analytically, and the results are compared with existing experimental data. Emphasis is given to the effects of three-dimensional unsteady aerodynamics on coupled flap-lag-torsion aeroelastic stability. Numerical results for the lead-lag damping are obtained from analysis by the moving-block method and are compared with experimental results. Agreement is excellent over the full range of parameters investigated, even at the higher collective pitch angles. Three-dimensional tip loss and unsteady inflow effects which were missing in previous analyses turn out to be important. C.D.

A90-29187
A STUDY OF APPROXIMATELY OPTIMAL CRUISING FLIGHT REGIMES OF VARIABLE-MASS AIRCRAFT [ISSLEDOVANIE PRIBLIZHENNO OPTIMAL'NYKH KREISERSKIKH REZHIMOV POLETA SAMOLETA PEREMENNOI MASSY]
O. V. BALABANOV and V. T. PASHINTSEV TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 3, 1989, p. 52-60. In Russian. refs
Copyright
An energy model of the controlled motion of variable-mass aircraft is used for the approximate synthesis of the optimal thrust and flight height control. A family of approximately optimal flight trajectories is obtained, with minimum fuel consumption for a given flight distance. Modified versions of the approximate synthesis are presented which allow for changes in the wind velocity component with height and for an additional constraint on the finite flight time. V.L.

A90-29382*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DIGITAL-FLUTTER-SUPPRESSION-SYSTEM INVESTIGATIONS FOR THE ACTIVE FLEXIBLE WING WIND-TUNNEL MODEL
BOYD PERRY, III, VIVEK MUKHOPADHYAY, SHERWOOD TIFFANY HOADLEY, STANLEY R. COLE, CAREY S. BUTTRILL (NASA, Langley Research Center, Hampton, VA) et al. IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and

Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1571-1581. refs
(AIAA PAPER 90-1074) Copyright

Active flutter suppression control laws were designed, implemented, and tested on an aeroelastically-scaled wind-tunnel model in the NASA Langley Transonic Dynamics Tunnel. One of the control laws was successful in stabilizing the model while the dynamic pressure was increased to 24 percent greater than the measured open-loop flutter boundary. Other accomplishments included the design, implementation, and successful operation of a one-of-a-kind digital controller, the design and use of two simulation methods to support the project, and the development and successful use of a methodology for online controller performance evaluation. Author

A90-29385#
ADAM 2.0 - AN ASE ANALYSIS CODE FOR AIRCRAFT WITH DIGITAL FLIGHT CONTROL SYSTEMS
V. JAMES SALLEE (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990. p. 1600-1610. refs
(AIAA PAPER 90-1077)

This paper presents an overview of a new computer code used for the analysis of the aeroservoelastic stability of an aircraft employing a digital flight control system. The computer code, ADAM 2.0, evolved as a result of the modifications and improvements made to another original Air Force computer code, ADAM. The modifications result from changes made to the original procedjure for integrating the model of the digital flight control system with the aeroelastic model of the aircraft. In addition, discretization schemes are compared. The major improvements arise from the techniques used to develop analytic functions of the unsteady generalized aerodynamic forces. These improvements are demonstrated together with results of a preliminary analysis of a current aircraft. Author

A90-30103
REAL TIME ESTIMATION OF AIRCRAFT ANGULAR ATTITUDE
G. SHADMON (Israel Aircraft Industries, Ltd., Engineering Div., Lod, Israel) IN: Identification and system parameter estimation 1988; IFAC/IFORS Symposium, 8th, Beijing, People's Republic of China, Aug. 27-31, 1988, Selected Papers. Volume 2. Oxford, England and Elmsford, NY, Pergamon Press, 1989, p. 1315-1320. refs
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This paper presents a new method of estimating aircraft angular attitude under real-time conditions. The basis for the estimation is the requirement of best possible compatibility between the current estimate and the time history of the past measurements. The characteristics of the estimation technique are (1) use of the quaternion formalism on characterizing the rotational motion, (2) adoption of the least-squares (LS) method as the tool for extracting the estimated quaternion out of the foregoing requirement, and (3) incorporation of the fading-memory technique as a means of reducing the sensitivity to modeling errors. The main advantage of this method is its extremely small computation burden. This is reflected by a lack of the usual operations of matrix inversion and matrix propagation in time. Author

A90-30105
AIRCRAFT FLIGHT CONTROL SYSTEM IDENTIFICATION
J. A. MULDER (Delft, Technische Universiteit, Netherlands) IN: Identification and system parameter estimation 1988; IFAC/IFORS Symposium, 8th, Beijing, People's Republic of China, Aug. 27-31, 1988, Selected Papers. Volume 2. Oxford, England and Elmsford, NY, Pergamon Press, 1989, p. 1327-1332. refs
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A novel approach to the identification of aircraft flight-control-system (FCS) models is proposed which utilizes accurate control force and displacement data obtained during short dynamic flight-test maneuvers. A reduced-order mathematical model of a conventional (rod-cable-crank) FCS is derived; the decomposition of the parameter-estimation problem is explained; the instrumentation and flight-test protocol for a Citation 500 business jet are described; and typical measurement data are compared with model predictions in graphs. Good agreement is obtained, resulting in successful identification of the elevator, aileron, and rudder FCS models. T.K.

A90-30703
MODELING AND ANALYSIS TOOLS FOR AIRCRAFT CONTROL SYSTEM EVALUATIONS
MARK R. ANDERSON, URI H. RABIN, and JAMES H. VINCENT (Systems Control Technology, Inc., Palo Alto, CA) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 286-293. refs
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A systematic approach for successful control system evaluations of future high-performance aircraft is presented. The approach involves the integration of several modeling and analysis techniques into one evaluation methodology. The evaluation methodology has been used successfully to evaluate several production fighter aircraft and rotorcraft flight control systems. The modeling tools discussed include linear model extraction from nonlinear simulations, linear model build-up, and equivalent system model reduction. Efficient techniques for validating and comparing complex linear models are also presented. The stability and handling-qualities- analysis tools used in the evaluation methodology result in direct comparisons of control-system characteristics with military flying qualities and flight-control-system specifications. Tool and technique descriptions are supplemented by lessons learned from previous flight-control evaluations. I.E.

A90-30704#
DIGITAL SIMULATION OF FLIGHT CONTROL SYSTEMS FOR POST-STALL AIRCRAFT
LISA MCCORMACK (U.S. Air Force Academy, Colorado Springs, CO) and DANIEL GLEASON (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 294-298.

Digital simulations of aircraft with normal-acceleration, pitch-rate, and angle-of-track command flight control systems capable of PST (poststall) flight were successfully developed. Analysis of test cases showed the shortcomings as well as the strengths of each configuration. The aircraft configured with the pitch-rate command flight control system exhibited the greatest pitch-roll and pitch-yaw coupling problems and was oversensitive in pitch. It is suggested that adjusting the gain slightly, adding pitch-roll and pitch-yaw crossfeeds and modifying the existing aileron-to-rudder and roll-rate-to-rudder interconnects should minimize this problem. The angle-of-attack command aircraft reacted sluggishly to pitch inputs. It is suggested that adding lead-lag compensation will lower the vehicle's rise time. I.E.

A90-30705#
FLYING QUALITIES LESSONS LEARNED - 1988
G. THOMAS BLACK and WILLIAM T. THOMAS (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 299-306. refs

The authors review five major areas of lessons learned in the discipline of flying qualities in 1988. Specifically, they examine flight-control system automatic limiters, the effects of Åsmall' aerodynamic changes, the effect of thrust increases, the effect of discretization of existing analog systems, and simulator evaluation results of some flight-control modes. Aircraft from which the lessons are drawn are the F-16, a conceptual agile fighter design, the E-8A, YA-7F, F-14A+/D, F-15, F-111, and F-15 S/MTD. I.E.

A90-30707#

RECONFIGURABLE FLIGHT CONTROLLER FOR THE STOL F-15 WITH SENSOR/ACTUATOR FAILURES

DONALD L. POGODA and PETER S. MAYBECK (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 318-324. refs

A multiple model adaptive controller that provides for reconfiguration in response to sensor and/or actuator failures is developed for an approach and landing profile for the short take-off and landing (STOL) F-15 aircraft. Each elemental controller within the multiple model controller is based on a command generator tracker/proportional plus integral/Kalman filter design, with residual monitoring used as the mechanism to select the appropriate controller. The elemental controllers are each based on an assumed system status: no failures or a single failed surface or sensor. Controller selection is evaluated for controller mixing based on all algorithm-computed probabilities of each elemental controller being the Åcorrect' controller to use. The entire multiple model controller is evaluated against a truth model with a selected failure, and then repeating the process for all failure modes of interest. I.E.

A90-30708

AN AIRCRAFT FLIGHT CONTROL RECONFIGURATION ALGORITHM

ROBERT L. SWAIM (Oklahoma State University, Stillwater), MARCELLO R. NAPOLITANO, and CLYDE E. GOODNER IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 325-332. refs

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An algorithm introduced by Robinson is applied to the aircraft flight-control reconfiguration problem. The determination of the desired control law, which can adapt in a very short period of time to major damage to a control surface, is obtained by making use of the recent control and response time histories. In addition, a method is proposed to efficiently distribute the reconfiguration task among all the remaining healthy control surfaces. The estimated model of the damaged aircraft used in this technique is obtained by using a multiple model Kalman filtering approach. The model estimation and the control algorithm have been codified in a computer simulation program for a six-degrees-of-freedom aircraft model. The simulation results of the reconfiguration are presented. I.E.

A90-30710

F/A-18 AILERON SMART SERVOACTUATOR

RICHARD J. MCLAUGHLIN and E. D. SHAW (H. R. Textron, Valencia, CA) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 338-345.

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A description is given of the Smart Actuator, that is, an actuator that contains its own electronics. The electronics package forms an integral part of the actuator, coexisting with the mechanical and hydraulic hardware in the same hostile environment. The goal of this effort was to design electronics for high temperature using the requirements of the F/A-18 Aileron (135 C). The electronics provide transparent control of the aileron with closed-loop operation, fault detection/isolation, redundancy management, and fail-op protection. Dual-channel fault isolation provides automatic shut-down of a channel when a fault is detected, and a damped mode of operation when a second channel failure is detected. I.E.

A90-30713#

LESSONS LEARNED IN THE DEVELOPMENT OF A MULTIVARIABLE CONTROL SYSTEM

DAVID J. MOORHOUSE (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) and ROBERT L. KISSLINGER (McDonnell Aircraft Co., Saint Louis, MO) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 364-371. refs

A primary objective of the STOL (short takeoff and landing) and Maneuver Technology Demonstrator (S/MTD) program is the development of an Integrated Flight/Propulsion Control (IFPC) system. The use of modern multivariable control theory was required for this program, but in implementation a combined classical and multivariable design approach has been found to be the most efficient. The architecture defined by the multivariable approach was chosen for some control modes and that defined by the classical approach was chosen for others. The problems overcome in realizing an effective and practical implementation are discussed. Finally, some recommendations for control-system research are presented. I.E.

A90-30714

DESIGN OF ADAPTIVE DIGITAL CONTROLLERS INCORPORATING DYNAMIC POLE-ASSIGNMENT COMPENSATORS FOR HIGH-PERFORMANCE AIRCRAFT

B. PORTER and C. L. BODDY (Salford, University, England) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 372-379. Research supported by SERC. refs

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It is shown that tunable digital controllers incorporating dynamic pole-assignment compensators for open-loop unstable multivariable plants with time-invariant parameters can be readily rendered adaptive so as to cope with such plants with time-invariant parameters. The effectiveness of such an adaptive digital controller incorporating a dynamic pole-assignment compensator is illustrated by designing an adaptive set-point tracking controller for the STOL (short takeoff and landing)/F-15 aircraft in a light condition for which this aircraft is open-loop unstable. It is demonstrated that the adaptive controller rapidly 'learns' the dynamical characteristics of the STOL/F-15 aircraft so that noninteracting set-point tracking is soon achieved with practically acceptable control-surface deflections. I.E.

A90-30715#

MULTIVARIABLE CONTROL DESIGN FOR THE CONTROL RECONFIGURABLE COMBAT AIRCRAFT (CRCA)

DARYL HAMMOND and JOHN J. D'AZZO (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 380-387. refs

Multivariable output feedback digital control laws are designed for the Control Reconfigurable Combat Aircraft (CRCA). The design incorporates the high-gain error-actuated proportional plus integral (PI) controller. Control law development and simulation are performed using the computer aided design program called MATRIXx. The CRCA design includes an all-flying canard with 30 deg of dihedral angle which prevents the normal separation of lateral and longitudinal equations because of high aerodynamic cross-coupling. Consequently, developing a satisfactory controller for all aircraft motion must include all of the control surfaces. The three control surfaces on each wing are operated together; so they are treated as one control effector. Thus, the five CRCA control inputs for this design consist of two canards, left trailing edge flaperon, right trailing edge flaperon, and rudder. The aircraft dynamics are linearized about three flight conditions ranging from high speed and low altitude, to high speed and high altitude. Fixed-gain PI controllers are designed at each flight condition for both the healthy aircraft and with a failed left canard and left trailing edge flaperon. Decoupling of the output variables is achieved and demonstrated by two maneuvers. Simulation indicates that the controller is very robust and output responses are fully satisfactory. I.E.

A90-30717
DEVELOPMENT OF HIGH ANGLE OF ATTACK FLYING QUALITIES CRITERIA USING GROUND-BASED MANNED SIMULATORS
DAVID J. WILSON and DAVID R. RILEY (McDonnell Aircraft Co., Saint Louis, MO) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 407-414. refs
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It is noted that the development of high-AOA (angle-of-attack) flying-qualities criteria using ground-based manned simulators presents unique problems for the flying-qualities engineer. These problems include modified aircraft motion to pilot inputs; an expanded motion environment at the pilot's station; the need for modified controllers and different types of command systems; and realistic flying qualities tasks. The modified aircraft motion to pilot inputs is inherent to this flight regime and it is asserted that pilot training will be required to operate the aircraft effectively. It is noted that the high-AOA motion environment will be difficult to accurately replicate in ground-based simulation and its physiological effects on the pilot need to be investigated. Novel command system types and controllers may be required to optimize aircraft performance for high-AOA maneuvering. Flying qualities tasks that allow ample evaluation time and isolate the proper axis can be developed for flying qualities evaluations. It is further noted that ground-based simulators can initially be used to develop flying-qualities criteria for the high-AOA flight regime but flight testing will be needed to validate these criteria. I.E.

A90-30794
A RECONFIGURABLE INTEGRATED NAVIGATION AND FLIGHT MANAGEMENT SYSTEM FOR MILITARY TRANSPORT AIRCRAFT
L. O. TAYLOR and K. W. MCELREATH (Rockwell International Corp., Collins Government Avionics Div., Cedar Rapids, IA) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 4. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 1775-1781.
Copyright

The authors describe the flight management and navigation system currently being developed for the German Air Force C-160 Transall airlifter and consider the implementation and operational characteristics of the newest generation of Collins military avionics systems. The system features a modular expandable architecture in both hardware and software. This system design approach is made feasible by a reconfigurable, multiprocessing software operating system. It allocates processing tasks according to the current system state to preserve the highest possible level of functionality in the event of failures. The primary system interface medium is the MIL-STD-1553B serial digital bus, and all software is in Ada. The modular multiprocessing system features identical processors performing independent tasks. These tasks can be reallocated in real time in response to failures, providing a depth of mission-critical survivability previously achievable only through massive redundancy. The operational benefits of the flight management system provide for the optional elimination of one crew member (navigator) and significantly improved workload and task times for the pilots and loadmaster. I.E.

A90-31277#
STATIC STABILITY AND CONTROL CHARACTERISTICS OF SCISSOR WING CONFIGURATIONS
KAMRAN ROKHSAZ and BRUCE P. SELBERG (Missouri-Rolla, University, Rolla) Journal of Aircraft (ISSN 0021-8669), vol. 27, April 1990, p. 294-299. Previously cited in issue 09, p. 1290, Accession no. A89-25009. refs
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A90-31282#
INTEGRATED STRUCTURE/CONTROL CONCEPTS FOR OBLIQUE WING ROLL CONTROL AND TRIM
TERRENCE A. WEISSHAAR (Purdue University, West Lafayette, IN) Journal of Aircraft (ISSN 0021-8669), vol. 27, April 1990, p. 326-333. refs
(Contract N62269-85-C-0268)
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The integrated design problem posed by the need for oblique wing aircraft aeroelastic roll trim at subsonic airspeeds is examined. It is shown that the need for roll trim is reduced when structural tailoring with advanced composite materials is used, but there is a maximum oblique wing sweep angle above which tailoring is ineffective. A formula for this sweep angle is developed. The need for a combination of asymmetrical aileron input and aeroelastic tailoring of a laminated wing structure is also examined. The design trade-off between structural tailoring to reduce the need for ailerons for roll trim and aileron control surface effectiveness to provide roll trim is illustrated using an example configuration. Tailoring the aileron size so that the aileron reversal dynamic pressure and the static aeroelastic divergence dynamic pressure of the restrained oblique wing are identical is also discussed. Author

A90-31283#
ACTIVE FLUTTER SUPPRESSION FOR A WING MODEL
G. L. GHIRINGHELLI, M. LANZ, and P. MANTEGAZZA (Milano, Politecnico, Milan, Italy) (ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1, p. 184-193) Journal of Aircraft (ISSN 0021-8669), vol. 27, April 1990, p. 334-341. Previously cited in issue 03, p. 270, Accession no. A89-13524. refs
(Contract CNR-86,00865,59)
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A90-31287#
SENSITIVITY DERIVATIVES OF FLUTTER CHARACTERISTICS AND STABILITY MARGINS FOR AEROSERVOELASTIC DESIGN
M. KARPEL (Technion - Israel Institute of Technology, Haifa) Journal of Aircraft (ISSN 0021-8669), vol. 27, April 1990, p. 368-375. Previously cited in issue 23, p. 3618, Accession no. A89-52562. refs
Copyright

A90-31480#
STUDIES OF PREDICTING DEPARTURE CHARACTERISTICS OF AIRCRAFT
HONG ZHANG (Shanghai Aircraft Design and Research Institute, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 8, March 1990, p. 32-38. In Chinese, with abstract in English. refs

After careful examination of the departure motion of aircraft, a new criterion is proposed for predicting departure characteristics of aircraft at high angles-of-attack by analyzing the closed-loop stability of aircraft under the control of an aileron. The stability is indicated by the analysis of the operator matrix of the nonlinear aircraft dynamic equations. Computations made on six aircraft departure characteristics show that the new criterion is good and sound, and agrees well with the Bihrle (1982) and Weissman (1975) criteria. Author

N90-18431# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
DISCRETE PROPORTIONAL PLUS INTEGRAL (PI) MULTIVARIABLE CONTROL LAWS FOR THE CONTROL RECONFIGURABLE COMBAT AIRCRAFT (CRCA) M.S. Thesis
JAMIE L. FOELKER Dec. 1989 158 p
(AD-A215664; AFIT/GE/ENG/89-12) Avail: NTIS HC A08/MF A01 CSCL 01/3

Multivariable control laws developed by Dr. Brian Porter of the University of Salford, England are used to successfully perform maneuvering tracking tasks with the NASA/Grumman Control Reconfigurable Combat Aircraft (CRCA). Porter's method is used to design discrete Proportional plus Integral (PI) control laws. Output and selected state rate feedback are used. The results in three no failure flight conditions show robust tracking control of the CRCA for five selected maneuvers. Single failures are introduced to test the ability of the fixed-gain designs to successfully control the aircraft and perform the maneuvers. The time responses show that discrete PI control law can make the CRCA successfully perform all five maneuvers for two of the three control surface failures investigated in two of the three point designs. The step response PI control law results in stable control for only one of three failure situations. GRA

N90-18432# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Guidance and Control Panel.
THE IMPLICATIONS OF USING INTEGRATED SOFTWARE SUPPORT ENVIRONMENT FOR DESIGN OF GUIDANCE AND CONTROL SYSTEMS SOFTWARE
EDWIN B. STEAR, ed. and JOHN T. SHEPHERD, ed. (GEC-Marconi Ltd., Borehamwood, England) 1990 192 p
(AGARD-AR-229; ISBN-92-835-0538-7) Copyright Avail: NTIS HC A09/MF A01; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive
The deliberations and conclusions of Working Group 8 of the Guidance and Control Panel of AGARD are summarized, which are: (1) to develop and consider a set of requirements for a high level language software support environment from a guidance and control systems viewpoint; (2) to evaluate the characteristics and capabilities offered by advanced language support environments, either existing or in the course of development, with respect to the requirements defined in 1; and (3) if necessary, to determine the modifications which would have to be contemplated to meet fully the needs expressed in 1. The Working Group attempted to consider all software design and development technologies which existed or were known to be under development at the time. Author

N90-18433# Thermacore, Inc., Lancaster, PA.
FLEXIBLE HEAT PIPE COLD PLATE Final Report, 2 Feb. - 30 Nov. 1988
NELSON J. GERNERT 13 Jan. 1989 71 p
(Contract N62269-88-C-0210)
(AD-A216053; S3912A; NADC-89067-60) Avail: NTIS HC A04/MF A01 CSCL 01/4
The Naval Air Development Center is taking action to improve the reliability of aircraft flight control hydraulic actuators. Feedback and loop closure electronics are being mounted on the actuator, thereby eliminating numbers of electrical conductors between the actuator and the flight control computer. Methods for the electronics are required to help assure reliability. The Thermacore effort documented in this report investigated the feasibility of using heat pipe technology to thermally protect the flight critical actuator electronics. The cooling method investigated used a flexible heat pipe cold plate that interfaced with the integrally connected flexible hose to a nearby heat sink. The flexible section accommodates relative motion between the actuator and the heat sink. The successful Phase 1 work program first established the design requirements; evaluated cold plate to actuator integration techniques; conducted analysis to select the best heat pipe material/working fluid system; and concluded with the design, fabrication and testing of a flexible heat pipe cold plate assembly that integrates with the SMART aileron actuator being developed by H.R. Textron. The cold plate transferred over 60 watts. This power exceeded the 44.5 watt requirement. GRA

N90-18434*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
APPLICATION OF VARIABLE-GAIN OUTPUT FEEDBACK FOR HIGH-ALPHA CONTROL
AARON J. OSTROFF Feb. 1990 11 p Previously announced in IAA as A89-52659
(NASA-TM-102603; NAS 1.15:102603) Avail: NTIS HC A03/MF A01 CSCL 01/3
A variable-gain, optimal, discrete, output feedback design approach that is applied to a nonlinear flight regime is described. The flight regime covers a wide angle-of-attack range that includes stall and post stall. The paper includes brief descriptions of the variable-gain formulation, the discrete-control structure and flight equations used to apply the design approach, and the high performance airplane model used in the application. Both linear and nonlinear analysis are shown for a longitudinal four-model design case with angles of attack of 5, 15, 35, and 60 deg. Linear and nonlinear simulations are compared for a single-point longitudinal design at 60 deg angle of attack. Nonlinear simulations for the four-model, multi-mode, variable-gain design include a longitudinal pitch-up and pitch-down maneuver and high angle-of-attack regulation during a lateral maneuver. Author

N90-19238 Princeton Univ., NJ.
A RULE-BASED PARADIGM FOR INTELLIGENT ADAPTIVE FLIGHT CONTROL Ph.D. Thesis
DAVID ANDREW HANDELMAN 1989 339 p
Avail: Univ. Microfilms Order No. DA8918852
Investigated here is the use of highly integrated symbolic and numeric processing in real-time knowledge-based system for enhanced automatic aircraft failure accommodation. A rule-based control technique is proposed whereby procedural activity is attained through the manipulation of declarative expressions. Rules are used to encode common-sense dependencies, expert knowledge on specific situations, and to invoke algorithmic mathematical procedures. Task execution occurs as a by-product of search through these knowledge base rules. Also proposed is a rule-based controller development system that utilizes a high-level symbolic LISP environment for preliminary system design. Automatic LISP-to-Pascal knowledge base translation is then used to provide dramatically increased execution speed and an environment for highly integrated symbolic and numeric computation. The utility of the control technique is demonstrated through the construction of a multi-microprocessor Rule-Based Flight Control System (RBFCS). Integrating methods of statistical hypothesis testing and rule-based automatic emergency procedure execution, the RBFCS is shown to accommodate multiple simulated failures affecting the electrical, hydraulic, and stability augment subsystems of a CH-47 helicopter. It is found that in addition to enabling significant control system capabilities, the rule-based control technique enhances designer productivity. Dissert. Abstr.

N90-19239*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LOW-SPEED WIND-TUNNEL INVESTIGATION OF THE FLIGHT DYNAMIC CHARACTERISTICS OF AN ADVANCED TURBOPROP BUSINESS/COMMUTER AIRCRAFT CONFIGURATION
PAUL L. COE, JR., STEVEN G. TURNER, and D. BRUCE OWENS Washington Apr. 1990 50 p
(NASA-TP-2982; L-16664; NAS 1.60:2982) Avail: NTIS HC A03/MF A01 CSCL 01/3
An investigation was conducted to determine the low-speed flight dynamic behavior of a representative advanced turboprop business/commuter aircraft concept. Free-flight tests were conducted in the NASA Langley Research Center's 30- by 60-Foot Tunnel. In support of the free-flight tests, conventional static, dynamic, and free-to-roll oscillation tests were performed. Tests were intended to explore normal operating and post stall flight conditions, and conditions simulating the loss of power in one engine. Author

N90-19240 Colorado Univ., Boulder.
NEUROCONTROL SYSTEMS AND WING-FLUID INTERACTIONS UNDERLYING DRAGONFLY FLIGHT Ph.D. Thesis

MARK HOLCOMBE KLISS 1989 173 p
Avail: Univ. Microfilms Order No. DA8923505

Studies were performed on the dragonfly, which exhibits a variety of flight modes from hovering to high speed escape. The experiments conducted focus on the neurocontrol strategies and wing-fluid interactions which underlie these flight modes. It appears that an understanding of the dragonfly flight control mechanisms can provide a more comprehensive picture of the control strategies utilized by insects during flight. A simplified model of wing-fluid interactions likely to support particular flight modes was investigated in order to determine the crucial kinematic variables to be controlled. The constraints imposed on dragonfly flight performance by the biomechanics of the flight hardware, and the composition and structure of the nervous system were identified. Specific experiments were then performed to provide insight into the fundamental neurocontrol strategies inherent to the dragonfly nervous system. These studies focused on the cellular, synaptic, and network properties of the ganglia, and the extent to which these properties shape the motor pattern output. Based on the aerodynamic, electrophysiological, histological, and neurophysiological results obtained, a model of dragonfly flight control mechanisms was proposed. Dissert. Abstr.

N90-19241*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, CA.

OUTPUT MODEL-FOLLOWING CONTROL SYNTHESIS FOR AN OBLIQUE-WING AIRCRAFT

JOSEPH W. PAHLE Apr. 1990 30 p
(NASA-TM-100454; H-1522; NAS 1.15:100454) Avail: NTIS HC A03/MF A01 CSCL 01/3

Recent interest in oblique-wing aircraft has focused on the potential aerodynamic performance advantage of a variable-skew oblique wing over a conventional or symmetric sweep wing. Unfortunately, the resulting asymmetric configuration has significant aerodynamic and inertial cross-coupling between the aircraft longitudinal and lateral-directional axes. Presented here is a decoupling control law synthesis technique that integrates stability augmentation, decoupling, and the direct incorporation of desired handling qualities into an output feedback controller. The proposed design technique uses linear quadratic regulator concepts in the framework of explicit model following. The output feedback strategy used is a suboptimal projection from the state space to the output space. Dynamics are then introduced into the controller to improve steady-state performance and increase system robustness. Closed-loop performance is shown by application of the control laws to the linearized equations of motion and nonlinear simulation of an oblique-wing aircraft. Author

N90-19420*# Kentucky Univ., Lexington. Dept. of Electrical Engineering.

YAW RATE CONTROL OF AN AIR BEARING VEHICLE

BRUCE L. WALCOTT *In* Alabama Univ., Research Reports: 1989 NASA/ASEE Summer Faculty Fellowship Program 46 p Dec. 1989
(Contract NGT-01-008-021)
Avail: NTIS HC A99/MF E06 CSCL 01/3

The results of a 6 week project which focused on the problem of controlling the yaw (rotational) rate the air bearing vehicle used on NASA's flat floor facility are summarized. Contained within is a listing of the equipment available for task completion and an evaluation of the suitability of this equipment. The identification (modeling) process of the air bearing vehicle is detailed as well as the subsequent closed-loop control strategy. The effectiveness of the solution is discussed and further recommendations are included. Author

09

RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

A90-27953

A REVIEW OF FLIGHT SIMULATION TECHNIQUES

MAX BAARSPUL (Delft, Technische Universiteit, Netherlands) Progress in Aerospace Sciences (ISSN 0376-0421), vol. 27, no. 1, 1990, p. 1-120. refs
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The evolution of flight simulator techniques and operations is described. A description is given of the main components of a piloted flight simulator, including the similarity between aircraft and simulator in cockpit layout, and flying controls based on the equipment and environmental cue fidelity required for training and research simulators. Visual systems now available and most widely used are described, and image generators and display devices for these systems are characterized. As faithful reproduction of aircraft motion requires large travel, velocity, and acceleration capabilities of the motion system, different types and applications of motion systems in airline training and research are indicated. The principles of mathematical modeling of the aerodynamic, flight control, propulsion, landing gear, and environmental characteristics are reviewed. In conclusion, the status of flight simulator technology is reviewed and future prospects in this area are discussed. R.E.P.

A90-28156

HIGHER HARMONIC AND TRIM CONTROL OF THE X-WING CIRCULATION CONTROL WIND TUNNEL MODEL ROTOR

W. A. WELSH and R. H. BLACKWELL, JR. (Sikorsky Aircraft, Stratford, CT) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 65-79. refs
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A wind tunnel test of a 1/6 scale aeroelastic X-wing model rotor was conducted in order to demonstrate that higher harmonic control (HHC) could effectively suppress fixed system vibration (4P) throughout a wide range of rotor speeds and forward velocities. A flexible man-in-the-loop HHC and trim control system was used simultaneously to reduce stand 4P acceleration and rotor balance 4P loads while maintaining rotor trim via automatic control of the 24-blade root pressure valves. With some exceptions, it is shown that 70 to 95 percent reductions in fixed system vibrations are realized. The control system also proved to be an invaluable aid in achieving rotor trim and blade load reductions when required. C.D.

A90-28254#

NON-ISENTROPIC EFFECTS ON THE WRDC 20 INCH HYPERSONIC WIND TUNNEL CALIBRATION

MELVIN L. BUCK and ALFRED C. DRAPER (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 19-28. refs

An experiment was conducted in the Wright Research and Development Center 20-in. hypersonic wind tunnel to assess nonisentropic effects on the test section Mach number. Pressure measurements were made on a blunt 5-deg cone. These pressures were then compared with a parabolized Navier-Stokes code to define the free-stream Mach number. The results indicate that the nonisentropic effects are not significant. There is no pronounced difference in the Mach number from that determined by the more conventional pitot pressure probe survey. I.E.

A90-28255*# Naval Postgraduate School, Monterey, CA.
DESIGN AND DEVELOPMENT OF A FACILITY FOR COMPRESSIBLE DYNAMIC STALL STUDIES OF A RAPIDLY PITCHING AIRFOIL
M. S. CHANDRASEKHARA (U.S. Navy-NASA Joint Institute of Aeronautics, Monterey, CA) and L. W. CARR (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 29-37. refs
(Contract AF-AFOSR-88-0010)

A facility for the study of dynamic stall of an airfoil undergoing a transient ramp-type pitching motion is described. The facility can produce pitch rates of 3600 deg/sec to an angle of attack of 60 deg by using a specially designed hydraulic drive with feedback control. The ramp motion generator can also generate arbitrary motion of the airfoil and thus can simulate an arbitrary aircraft maneuver. A unique airfoil support system allows unobstructed flow visualization including the complete airfoil contour, thus permitting the use of nonintrusive optical diagnostic methods for flow measurement close to the surface as well as simultaneous far-field measurements. Schlieren pictures obtained during the study reveal the instantaneous density gradients associated with dynamic stall, even under conditions of very low Mach numbers. I.E.

A90-28256
A NEW DATA ACQUISITION, DISPLAY AND CONTROL SYSTEM FOR THE ARA TRANSONIC WIND TUNNEL
DAVID G. COULTON (Aircraft Research Association, Ltd., Bedford, England) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 38-49.
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A new data acquisition system has been designed and manufactured by the systems department of the Aircraft Research Association (ARA) for use in the transonic wind tunnel at Bedford, England. This system is based on a single-board computer utilizing a 68020 processor operating on a VME bus. The calibration system, which is referable back to national standards, supplemented by a precision bridge circuit, constantly assures the user of the quality of data being recorded. Consideration is given to the development of data logging and the system requirements and specifications. The most important constituent parts of the system are described, as are several planned enhancements. I.E.

A90-28257
OBSERVATION AND ANALYSIS OF SIDEWALL EFFECT IN A TRANSONIC AIRFOIL TEST SECTION
YAOXI SU (Northwestern Polytechnical University, Xian, People's Republic of China) and W. PUFFERT-MEISSNER (DLR, Brunswick, Federal Republic of Germany) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 50-56. refs
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Oil flow tests were conducted to investigate the sidewall effect in transonic airfoil testing. Features of each type of flow pattern are described. It is found that the flow pattern develops systematically with the increase of Mach number and the angle of attack as a result of the development of sidewall effects. The sidewall effects of supercritical flow are found to be very different from those of subcritical flow and have a more pronounced influence on the measurements. Different hypotheses on the principle of sidewall effects are discussed. It is suggested that the sidewall effects are mainly caused by the displacement effect of the sidewall boundary layer. I.E.

A90-28260* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A TRANSITION DETECTION STUDY AT MACH 1.5, 2.0, AND 2.5 USING A MICRO-THIN HOT-FILM SYSTEM
CHARLES B. JOHNSON and DEBRA L. CARRAWAY (NASA, Langley Research Center, Hampton, VA) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 82-94. refs
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A boundary-layer transition detection study was conducted in the NASA Langley unitary plan wind tunnel with an array of microthin hot films on a flat plate at Mach numbers 1.5, 2.0, and 2.5 and Reynolds numbers (1.0-4.5) x 10 to the 6th/ft. Transition locations were obtained online from the variation of normalized rms voltages from an array of hot-film sensors for both natural transition and a grit-induced wedge of turbulence. The effects of Mach number and Reynolds number on the location and length of the transition region for the two types of transition are presented from the online data. Also shown are the unit Reynolds number effects on transition Reynolds number, voltage-versus-time traces, spectra, and the data-acquisition system. I.E.

A90-28281#
DEVELOPMENT AND EXTENSION OF DIAGNOSTIC TECHNIQUES FOR ADVANCING HIGH SPEED AERODYNAMIC RESEARCH
DANIEL M. PAROBEK, MATTHEW J. WAGNER, HENRY D. BAUST, and JOHN E. LEUGERS (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 332-342. refs

Diagnostic techniques are developed for high-speed turbulent boundary-layer studies in Mach 3 and Mach 6 high-Reynolds-number facilities and flow interactions in the low-density 51-cm hypersonic wind tunnel at Mach 12 and 14. Consideration is given to direct measurement of skin friction and heat transfer on smooth and rough surfaces, electron-beam flow visualization, hot-wire anemometry, flow speeding for LDV measurements, and unsteady pressure measurements on model surfaces. Emphasis is placed on combining techniques for more complete characterization of the phenomena being studied. I.E.

A90-28282
SOME PROBLEMS ON 'INTELLIGENCE' OF WIND TUNNEL TESTING
T. V. KORNEEVA, V. A. DOBROVOL'SKII, and IU. A. RYZHOV (Moskovskii Aviatsionnyi Institut, Moscow, USSR) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 343-349. refs
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The characteristics of the application of artificial intelligence in wind tunnel testing are considered. A deterministic-structure model and a variable-structure model of intelligence are suggested. The hardware realization issues are analyzed, as well as problems of efficiency evaluation of wind-tunnel-testing intelligence. I.E.

A90-28287
INFLUENCE OF WIND TUNNEL CIRCUIT INSTALLATIONS ON TEST SECTION FLOW QUALITY
HORST OTTO (DLR, Brunswick, Federal Republic of Germany) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 410-415.
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Investigations in the low-speed wind tunnel of the DLR at Braunschweig have shown that fairly strong flow disturbances which are produced by installations in the tunnel circuit upstream of the settling chamber do not penetrate into the test section, whereas thin soldered seams in the settling chamber screens cause a deficit in total pressure and an increase in turbulence in the test section flow. The effect is strongest for seams in the last screen and decreases for seams in screens which are installed upstream of the last one. The disturbances are amplified if seams are located one behind the other. I.E.

A90-28288

COMPUTER CONTROLLED TEST BENCH FOR AXIAL TURBINES AND PROPELLERS

A. H. RODRIGUES and A. RESTIVO (Porto, Universidade, Portugal) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 416-421. Research supported by the Ministry of Industry of Portugal and NATO.

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The experimental facility, measurement instrumentation, and preliminary tests carried out with a small-scale model of a wind turbine are described. Particular attention is given to the measurement technique, developed to cope with the small dimensions of the model turbine and correspondingly low torque and power. The tests made use of a low-speed closed-circuit tunnel, with a variable air speed of up to 13 m/sec. In the new test bench, a microcomputer is used to set and monitor the turbine speed and to measure and record instantaneous torque and power, as well as the main working parameters of the wind tunnel. Regulation of braking torque is achieved with a simple yet flexible generator load circuit, and the microcomputer-based system allowed the measurement of complete torque/speed curves with little human intervention. Preliminary results show that this facility provides a versatile tool for the investigation of small-scale axial turbines. I.E.

A90-28289*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

DEVELOPMENT OF A DUAL STRAIN GAGE BALANCE SYSTEM FOR MEASURING LIGHT LOADS

PAUL W. ROBERTS (NASA, Langley Research Center, Hampton, VA) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 422-433. refs

A strain-gage-balance (SGB) force-measurement system is described which was designed to meet light-load requirements for an airfoil model tested in the NASA Langley low-turbulence pressure tunnel (LTPT). This system was developed to obtain direct force data needed to verify calculated pressure/force correlations used in previous aerodynamic tests. The three-component force-measurement system was designed so that the SGBs would simultaneously support and measure the following loads: weight of the airfoil (approximately 3.0 lbf); 8.0 lbf of lift; 0.5 lbf of drag; and 16.0 in. lbf of pitching moment. In addition to these design loads, the system was required to withstand 100-percent overload on all three components. The system comprises an airfoil, two SGBs, a thermal flexure, and a mounting plate. The installation of the system in the LTPT is also discussed. I.E.

A90-28292

STATUS OF THE DEVELOPMENT PROGRAMME FOR INSTRUMENTATION AND TEST TECHNIQUES OF THE EUROPEAN TRANSONIC WINDTUNNEL - ETW

D. SCHIMANSKI (ETW GmbH, Cologne, Federal Republic of Germany) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 450-459. refs

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Feasibility studies concerned with instrumentation and test techniques for the ETW are summarized. During the functional design phase (1986-88), instruments and techniques for application in cryogenic wind tunnels were investigated. The studies were focused on items which might influence the design of the test section area (flow field observation, surface flow visualization, model attitude, and deformation measurement) and which might improve the test capability of the facility (engine simulation, model handling, and balance calibration). It is noted that precise knowledge of model loads, model position, model configuration, and the surrounding flow conditions is essential for testing Reynolds-number effects. Standard equipment (strain-gage balances, light sources, cameras, windows, etc.) is being investigated. The ETW operating conditions (cryogenic temperatures and limited access) require special arrangements with innovative design and creative ideas even for these standard items. I.E.

A90-28293

INSTRUMENTATION AND OPERATION OF NDA CRYOGENIC WIND TUNNEL

YUTAKA YAMAGUCHI, HIDEKEI KABA, NOBUMITSU KURIBAYASHI, YASUO NAKAUCHI (Defense Academy, Yokosuka, Japan), SHIZUYUKI YOSHIDA (Japan Defense Agency, Tokyo, Japan) et al. IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 460-469. refs

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The Japanese NDA 0.06 x 0.3-m cryogenic wind tunnel was constructed in 1985 for testing transonic airfoils and other basic research. Design choices included stainless steel SUS 304 as the material for the pressure shell, a centrifugal compressor, and external insulation. Although no information was available on problems using SUS 304 at cryogenic temperature, and although the thermal conductivity of SUS 304 is worse than that of Al alloys, only eight thermocouples were installed to monitor the thermal condition of the shell. The original temperature control (manual control of liquid N2 injection into the tunnel circuit) was found to be inadequate because the settling time of the total temperature took about 15 min when the rotational speed of the compressor was changed. The total-pressure control systems were modified to simple automatic PID controls; as a result, the control of both pressure and temperature was greatly improved (the settling time of temperature was greatly reduced). I.E.

A90-28294

FULLY AUTOMATIC CALIBRATION MACHINE FOR INTERNAL 6-COMPONENT WIND TUNNEL BALANCE INCLUDING CRYOGENIC BALANCES

BERND EWALD (Darmstadt, Technische Universitaet, Federal Republic of Germany), PETER GIESECKE, LUBOMIR POLANSKY, and TIMM PREUSSER (Carl Schenck AG, Darmstadt, Federal Republic of Germany) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 470-476.

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An automatic calibration machine for calibrating internal wind-tunnel balances is described. The automation is mainly achieved by using a specially designed force measuring device, similar to an external wind-tunnel balance. The loading is performed by means of six force generators, according to the six aerodynamic components of the balance. Consideration is given to the relevant aspects of accuracy, repeatability, and signal resolution; the mechanical design of the calibration rig; the controlling and safeguarding of the applied forces; and some general aspects of the positioning and alignment of the internal balance to be calibrated. I.E.

A90-28296
EXTERNAL 6-COMPONENT WIND TUNNEL BALANCES FOR AEROSPACE SIMULATION FACILITIES
TIMM PREUSSER and LUBOMIR POLANSKY (Carl Schenck AG, Darmstadt, Federal Republic of Germany) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 488-495.
Copyright
The measurement function of wind-tunnel balances is to separate vectorially the force vector K into the three x-y-z coordinate force directions or moments. The state of the art for external balances is strain-gage platform balances with computer separation of forces and moments. On the basis of experience gained with such balances, a new type of balance has been developed which combines the advantages of computer separation with the advantages of both platform- and pyramidal-type balances. This allows for a significant reduction of the load cells required for calibration of different heights within the test section and for considerable improvement of measurement accuracy of roll, pitch, and yaw moments. I.E.

A90-28300
APPLICATIONS OF INFRA-RED THERMOGRAPHY IN A HYPERSONIC BLOWDOWN WIND TUNNEL
A. HENCKELS and F. MAURER (DLR, Cologne, Federal Republic of Germany) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 516-524. refs
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IR imaging is applied to the measurement of surface temperature distributions on models exposed to a hypersonic flow field. A number of IR images are shown which demonstrate the advantages and limitations of this measurement technique. Combined with image processing on a personal computer, IR thermovision proves to be a powerful tool for obtaining a quick survey of the surface temperature distribution on wind-tunnel models. Due to the high framing rate of the camera system used, it is possible to calculate the time-dependent heat flux from the flow to the model surface from the recorded temperature data. All the examples are taken from experiments carried out with different kinds of models at the DLR H2K blowdown facility at Cologne. I.E.

A90-28302
A NOVEL TECHNIQUE FOR AERODYNAMIC FORCE MEASUREMENT IN SHOCK TUBES
K. W. NAUMANN and H. ENDE (Saint-Louis, Institut Franco-Allemand de Recherches, France) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 535-544. refs
Copyright
A novel measurement technique has been developed for aerodynamic force measurement in the Institute of Saint-Louis shock tunnel. Its key feature is a mounting support which releases the test model and tightens it again after a free-flight duration of 10-15-msec. This short time of free flight allows for the installation of wirings, because the model travels only some millimeters within the test time. Thus the accelerations can be recorded directly, as can up to six components, since no restraint is effective. This technique facilitates optimization with regard to stiffness, damping, and stability. I.E.

A90-28305
A NEW TYPE OF CALIBRATION RIG FOR WIND TUNNEL BALANCES
G. I. JOHNSON (Flygtekniska Forsogsanstalten, Bromma, Sweden) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 562-582.
Copyright
A new balance-calibration rig has been designed and built for the T1500 wind tunnel, with applicability to a large variety of balances, including half-model as well as sting-type balances with one to six components. The typical load capacity range is + or - 50 kN normal force. The rig is automatic, with calibration loads generated by pneumatic actuators controlled by a dedicated computer. Calibration loads are determined via precision transducers. A nonrepositioning principle has been used, with correction of component loads due to balance deflection under load. Data acquisition and the correction of components are also controlled by computer. This rig has proved to give the same accuracy and more than 50-percent reduction in calibration time compared to previous methods. Another important advantage is that calibration can be carried out without the need to lift heavy weights. I.E.

A90-29185
OPTIMAL CONDITIONS OF FLOW TURBULENCE SUPPRESSION IN THE WORKING SECTION OF A WIND TUNNEL USING SCREENS LOCATED IN THE PRECHAMBER [OPTIMAL'NYE USLOVIIA GASHENIIA TURBULENTNOSTI POTOKA V RABOCHEI CHASTI AERODINAMICHESKOI TRUBY S POMOSHCH'IU SETOK, USTANOVLENNYKH V FORKAMERE]
G. I. DERBUNOVICH, A. S. ZEMSKAIA, E. U. REPIK, and IU. P. SOSEDKO TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 3, 1989, p. 37-43. In Russian. refs
Copyright
The use of deturbulizing screens in wind tunnels is discussed. It is shown that the optimal ratios between the geometrical dimensions of deturbulizing screens and the distance x between the screens and the test section determined for the case of plane-parallel flow remain valid for flow in a wind tunnel of varying cross section if the actual distance x is replaced by an equivalent distance, with allowance made for changes in flow velocity along the wind tunnel. V.L.

A90-29241#
AN APPLICATION OF STRUCTURAL OPTIMIZATION IN WIND TUNNEL MODEL DESIGN
MARK FRENCH (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 127-134.
(AIAA PAPER 90-0956)
An approach is suggested for the stiffness design of aeroelastically scaled wind tunnel models. The object of designing the model is to make a structure whose stiffness matches a desired stiffness distribution. The design problem can be treated as a constrained optimization problem. A structural design code was used to design a model structure so that it had predetermined stiffness properties. To verify the results, a test specimen was fabricated and tested using laser holography. Author

A90-29924
A TEST FACILITY FOR HIGH-PRESSURE HIGH-TEMPERATURE COMBUSTION CHAMBERS [MONTAGE D'ESSAIS DE CHAMBRE DE COMBUSTION A HAUTE PRESSION ET HAUTE TEMPERATURE]
A. CADIOU (ONERA, Chatillon-sous-Bagneux, France) Revue Francaise de Mecanique (ISSN 0373-6601), no. 4, 1989, p. 417-424. In French.
Copyright
High pressure and temperature levels prevailing downstream of the last stage of a turbine engine compressor are provided in a new test facility for advanced unducted fan engines at the

Palaiseau Center of ONERA. This facility will permit testing of future turbojet engines operating at temperature and pressure levels of 1000 K and 40 bar, respectively. At these operating levels, the kinetics of fuel combustion is highly accelerated, and thus the heat levels of the combustion chamber walls and in particular of the fuel injectors become critical. It is noted that testing combustion chambers under realistic flow conditions is a prerequisite for final qualification of a turbojet engine hot section, and this new facility will provide the necessary capacity to enhance present and future combustion development. R.E.P.

A90-30251
NUMERICAL SIMULATION OF AN ADAPTIVE-WALL WIND-TUNNEL - A COMPARISON OF TWO DIFFERENT STRATEGIES
G. P. RUSSO and G. ZUPPARDI (Napoli, Universita, Naples, Italy) L'Aerotecnica - Missili e Spazio, Dec. 1987, p. 239-249. Research sponsored by MPI. refs
Copyright

A numerical simulation of the adaptive wall wind tunnel (AWWT) at the Institute of Aerodynamics in Naples is performed (1) to obtain information on the design of the adaptation system, as well as preliminary insight into the expected data quality; and (2) to compare two wall adaptation strategies: the WAS developed by Goodyer, Judd, and Wolf (1976), and the FLEXWALL developed by Everhart (1983). Both strategies, though different, are shown to be amenable to the same theoretical approach (Cauchy integral formula for analytic functions). The AWWT response is simulated by a numerical code based on the Douglas-Neumann source panel method, which computes the 2-D, inviscid, subsonic flow past the model in the presence of the two flexible tunnel walls. Numerical tests are performed on a NACA 0012 airfoil, in the angle-of-attack range from 0 to 10 deg, the test section height being equal to the model chord. The results show the effectiveness of both strategies, the WS being slightly superior in accuracy and computation time. N.B.

A90-30716#
THE STOL MANEUVER TECHNOLOGY DEMONSTRATOR MANNED SIMULATION TEST PROGRAM
KENNETH A. FEESER, JAMES M. ZEH, and DAVID B. LEGGETT (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 398-406.

A description is given of the STOL (short takeoff and landing) Maneuver Technology Demonstrator (S/MTD) simulation, a high-fidelity pilot-in-the-loop motion base simulation. The simulation was used to evaluate takeoff, landing, and air-to-air tasks before first flight of the S/MTD aircraft to improve aircraft flying qualities, conduct engineering research, and insure safety of flight. 208 hours of pilot-in-the-loop evaluations were conducted. The authors describe the simulation hardware, test approach/results of the Pilot Vehicle Interface (PVI), and flying qualities and aircraft failure evaluations in the STOL landing (SLAND) flight control system mode. I.E.

A90-30729#
STRATEGIC AIRCRAFT ENGINEERING DESIGN SIMULATION
THOMAS B. GREEN, BRADLEY D. PURVIS, and WILLIAM P. MARSHAK (USAF, Armstrong Aerospace Medical Research Laboratory, Wright-Patterson AFB, OH) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 742-745. refs

An effort is made to demonstrate the concept that engineering simulators such as B-1B ERS (Engineering Research Simulator) can provide a timely and cost-effective method of prototyping and evaluating certain selected changes in controls, displays, and avionics flight software while simultaneously providing up-to-date operational training. Several factors contribute to this environment, including: (1) a readily adaptable engineering development simulation device capable of rapid configuration changes, with simulator configuration control vested in an independent program office (which permits the simulator adaptations necessary to perform studies), and (2) an independent third-party government agency capable of performing credible research, whose research is additionally considered to be unbiased by all of the other parties responsible for system design. It has been shown that the B-1B ERS is both a valuable engineering design assessment device and a reliable primary ground training simulator for B-IB aircrews. I.E.

A90-30734#
RESEARCH IN A HIGH-FIDELITY ACCELERATION ENVIRONMENT
JOSEPH P. CAMMAROTA (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 778-782. refs

The lightweight cockpit (LWC) installed in the human centrifuge at NADC is one approach to creating an acceleration environment similar to that of tactical aircraft. This centrifuge is capable of very high onset and sustained accelerations. The pilot flies an aircraft simulation to maintain a target aircraft inside the gun pipper of a head-up display. The pilot is in complete control of the centrifuge through the simulation, and if the target tracking is successful, the centrifuge produces an acceleration profile that matches the target aircraft. The LWC simulation has a performance envelope which exceeds that of current inventory aircraft. The display system is a high-resolution wide-FOV computer graphics system which presents a real-world gaming area, an aerial target aircraft, and a high-fidelity head-up display. The aerial target flies profiles that are either actual engagements recorded from air combat maneuvering ranges or flights recorded using the enhanced aircraft model simulation. I.E.

A90-30770
ADVANCED TECHNOLOGY ATE FOR FUEL ACCESSORY TESTING
DAVID C. THOMAN and LARRY L. HESS (Allied-Signal Aerospace Co., Bendix Engine Controls Div., South Bend, IN) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 1406-1413. refs
Copyright

The current state of automation and systems technologies is reviewed, and it is shown that the judicious choice and integration of such technologies provides a sound platform for implementation of advanced fuel-accessory test-system concepts. Totally integrated test facilities parcel commands and share data as needed to meet throughput, reliability, and maintainability goals. Such a facility exploits advanced testing strategies (nonstatic, on-condition, and learn mode) and maintenance strategies (built-in test, expert diagnostics, and autocalibration) to accelerate testing and assure high test-station availability. Interactive video/graphics provides pictorial information to aid the operator in the adjustment and repair operation as well as in evaluation, calibration, and repair of the automated test equipment (ATE). Nonproductive testing is thus minimized by the early identification of faults and quick decisions on repair/reject actions. I.E.

A90-31248#
NEW LIGHT ON WIND TUNNEL LASERS
RICHARD DEMEIS Aerospace America (ISSN 0740-722X), vol. 28, April 1990, p. 44, 45.
Copyright

The use of lasers in wind tunnel flow visualization and measurements is reviewed. The error sources in laser velocimetry are discussed, including optics, data gathering electronics, data processing, and seeding. Experiments at NASA-Langley to study the problem of particle lag are examined, including tests using a phase Doppler particle analyzer to survey the velocity of droplets with different sizes along the stagnating center streamline. Also, a correction method using a computational model as the velocity reference is described. R.B.

A90-31279#
AUGMENTING FLIGHT SIMULATOR MOTION RESPONSE TO TURBULENCE
LLOYD D. REID (Toronto, University, Canada) and PAUL A. ROBINSON Journal of Aircraft (ISSN 0021-8669), vol. 27, April 1990, p. 306-311. refs
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When flight simulator motion systems are tuned for acceptable response to pilot control inputs, it is found that their response to turbulence may be unduly attenuated. The motion augmentation technique described in this paper allows the designer to increase the simulator's motion response to turbulence without otherwise altering its flight characteristics. The method employs a second set of flight equations excited only by the turbulence signals. The output from these equations is added to that from the primary simulation flight equations before being fed to the motion system. A sample case is developed showing its successful application to the heave channel of the University of Toronto Institute for Aerospace Studies Flight Research Simulator. Author

A90-31281#
WALL-INTERFERENCE CORRECTIONS FOR PARACHUTES IN A CLOSED WIND TUNNEL
J. MICHAEL MACHA and ROBERT J. BUFFINGTON (Sandia National Laboratories, Albuquerque, NM) Journal of Aircraft (ISSN 0021-8669), vol. 27, April 1990, p. 320-325. Previously cited in issue 09, p. 2123, Accession no. A89-35217. refs
(Contract DE-AC04-76DP-00789)

A90-31302#
INFRARED THERMOGRAPHY IN BLOWDOWN AND INTERMITTENT HYPERSONIC FACILITIES
G. SIMEONIDES, J. F. WENDT (Institut von Karman de Dynamique des Fluides, Rhode-Saint-Genese, Belgium), P. VAN LIERDE, S. VAN DER STICHELE, and D. CAPRIOTTI Journal of Thermophysics and Heat Transfer (ISSN 0887-8722), vol. 4, April 1990, p. 143-148. Previously cited in issue 09, p. 1294, Accession no. A89-25036. refs
Copyright

N90-19242*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
COMPARISON BETWEEN DESIGN AND INSTALLED ACOUSTIC CHARACTERISTICS OF NASA LEWIS 9- BY 15-FOOT LOW-SPEED WIND TUNNEL ACOUSTIC TREATMENT
MILO D. DAHL and RICHARD P. WOODWARD Washington Apr. 1990 28 p Presented at the 115th Meeting of the Acoustical Society of America, Seattle, WA, 16-20 May 1988
(NASA-TP-2996; E-4981; NAS 1.60:2996) Avail: NTIS HC A03/MF A01 CSCL 14/2

The test section of the NASA Lewis 9- by 15-Foot Low-Speed Wind Tunnel was acoustically treated to allow the measurement of sound under simulated free-field conditions. The treatment was designed for high sound absorption at frequencies above 250 Hz and for withstanding the environmental conditions in the test section. In order to achieve the design requirements, a fibrous, bulk-absorber material was packed into removable panel sections. Each section was divided into two equal-depth layers packed with material to different bulk densities. The lower density was next to the facing of the treatment. The facing consisted of a perforated plate and screening material layered together. Sample tests for normal-incidence acoustic absorption were also conducted in an impedance tube to provide data to aid in the treatment design. Tests with no airflow, involving the measurement of the absorptive properties of the treatment installed in the 9- by 15-foot wind tunnel test section, combined the use of time-delay spectrometry with a previously established free-field measurement method. This new application of time-delay spectrometry enabled these free-field measurements to be made in nonanechoic conditions. The results showed that the installed acoustic treatment had absorption coefficients greater than 0.95 over the frequency range 250 Hz to 4 kHz. The measurements in the wind tunnel were in good agreement with both the analytical prediction and the impedance tube test data. Author

10

ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

A90-29686*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
COMPUTATIONAL REQUIREMENTS FOR HYPERSONIC FLIGHT PERFORMANCE ESTIMATES
UNMEEL B. MEHTA (NASA, Ames Research Center, Moffett Field, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 27, Mar.-Apr. 1990, p. 103-112. Previously cited in issue 18, p. 2774, Accession no. A89-43193. refs
Copyright

11

CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

A90-27679
FATIGUE LIFE PREDICTION METHOD FOR GAS TURBINE ROTOR DISK ALLOY FV535
TAKESHI HORIKAWA (Ryukoku University, Otsu, Japan), TOMONOBU OKADA, and TOSHIYASU TSUNENARI (Kawasaki Heavy Industries, Ltd., Technical Institute, Akashi, Japan) Japan Society of Materials Science, Journal (ISSN 0514-5163), vol. 39, Jan. 1990, p. 82-88. In Japanese, with abstract in English. refs
Copyright

The adaptability of the fatigue strength evaluation method proposed earlier by the authors for the fatigue life prediction of the piston crown of a diesel engine was applied to evaluate fatigue life of a rotor disk made of martensite stainless steel FV535. Results indicate that the fatigue crack initiation life of a notched specimen under constant stress amplitude can be well predicted using Koe's or Neuber's methods. The fatigue life prediction method proposed by the authors was found to predict well the fatigue life of a smooth specimen in the region of higher stress than the fatigue limit, by using the interaction coefficient C of 0.3. However, in the region of stress near the fatigue limit, the method predicted very conservative life, and the coefficient C was more than 5. I.S.

A90-27681
RECRYSTALLIZATION BEHAVIOR OF NICKEL-BASE SINGLE CRYSTAL SUPERALLOYS
YOSHIO OHTA, YUKIYA G. NAKAGAWA, and JUNJI TSUJI (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) Japan Institute of Metals, Journal (ISSN 0021-4876), vol. 54, Jan. 1990, p. 84-92. In Japanese, with abstract in English. refs
Copyright

The effect of recrystallization of nickel-base single-crystal superalloys (Alloy 454, TMS 26, TMS 12-2, and CMSX-2) on the creep strength was investigated using samples of alloys with intentionally induced recrystallized layers of various depths. The susceptibility dependence was examined by reheating samples after tensile tests. Results showed that the recrystallization took place in all of the alloys at temperatures above 1273 K and that the grain size of the recrystallized regions depended on the reheating temperature. The creep strength of the alloys was reduced by recrystallization, and the degree of this decrease was related to the decrease of the load-bearing cross-sectional area due to recrystallization. I.S.

A90-28003#

A STUDY ON FLAW DETECTION METHOD FOR CFRP COMPOSITE LAMINATES. I - THE MEASUREMENT OF CRACK EXTENSION IN CFRP COMPOSITES BY ELECTRICAL POTENTIAL METHOD

KAZUMASA MORIYA (Defense Academy, Yokosuka, Japan) and TAKASHI ENDO (Japan Defense Agency, Tokyo) Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811), vol. 32, Feb. 1990, p. 184-196. refs

An in-service flaw detection and estimation method for CFRP composites using their electrical conductivity in the direction transverse to fiber axes is developed. It involves passing a constant current through composites and measuring the electrical potential, which changes as the crack advances. The network analysis of the random lattice model of CFRP composites shows that, even in the plane normal to the fiber direction, CFRP composites can be considered electrically homogeneous on a gross scale, i.e., on a scale of dimensions dozens of times as large as fiber diameter. The analysis also shows that the method can detect a small increment of crack growth in CFRP composites with only a fraction of current that is required for metals. Author

A90-28189

IMPROVEMENT IN STRUCTURAL INTEGRITY AND LONG TERM DURABILITY OF AEROSPACE COMPOSITE COMPONENTS

ASHOK K. MUNJAL (Kaman Aerospace Corp., Bloomfield, CT) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 477-487. refs

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This paper addresses the effect of various factors which influence the structural integrity and long-term durability of composite components for applications in aircraft and rotorcraft. Various designs, materials, processing and manufacturing approaches to optimizing these factors are discussed. Sources of manufacturing effects are reviewed, and methods of improving impact damage resistance, environmental resistance, joints and attachments are addressed, emphasizing the advantages of braiding. Reliability and maintainability are discussed. C.D.

A90-28191

THE USE OF FIBRE REINFORCED THERMOPLASTICS FOR HELICOPTER PRIMARY STRUCTURES AND THEIR ENGINEERING SUBSTANTIATION

S. P. SPURWAY (Westland Helicopters, Ltd., Yeovil, England) and A. C. DUTHIE (Westland, Inc., Arlington, VA) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 497-507. Research supported by the Ministry of Defence Procurement Executive. refs

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A flight-rated helicopter horizontal stabilizer and fin assembly for helicopters manufactured from fiber-reinforced thermoplastic composite materials has been designed, manufactured, and tested. The selection of materials is summarized and three methods of component fastening and attachment which were evaluated for use with thermoplastic composite components are described. The manufacturing and process development is addressed, including environmental and damage tolerance. The structural configuration, structural design and analysis, and testing of the component are discussed, as are design optimization and cost and weight analysis. C.D.

A90-28192

EVALUATION OF 3-D REINFORCEMENTS IN COMMINGLED, THERMOPLASTIC STRUCTURAL ELEMENTS

GLENN T. ROSSI (Boeing Helicopters, Philadelphia, PA) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 509-515. refs

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Two damage-tolerance design concepts, z-direction stitched two-dimensional laminates and fully three-dimensional braided composites, which use commingled graphite thermoplastic yarns are studied experimentally and using a series of advanced NDE methods. Damage initiation occurred at slightly lower energy levels in the stitched compression-after-impact (CAI) specimens compared to unstitched specimens. Overall residual compressive strength was better for the stitched specimens. Stitched residual strength improved over that of unstitched specimens with increasing damage energy. The data on three-dimensional braided composites indicates that CAI strength is the same or better than that in stitched two-dimensional fabric laminates using the same commingled yarn in each specimen. C.D.

A90-28193

ANALYSIS AND TESTING OF FIBER-REINFORCED THERMOPLASTIC COMPOSITE VERTICAL STABILIZER SKINS FOR AN ADVANCED ATTACK HELICOPTER

ALLYNE KAIZOJI (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 517-519.

Copyright

A project was undertaken to demonstrate the feasibility of using thermoplastic composites for primary structures. The left- and right-hand vertical stabilizer skins on an advanced attack helicopter were replaced with fiber-reinforced thermoplastic (FRTP). Aluminum skins of .050-inch thickness are currently installed on the helicopter. Carbon/polyetheretherketone (carbon/PEEK) was chosen as a replacement for the aluminum. A static analysis of the FRTP skins was performed. A symmetric laminate of ten +/- 45 deg plies was required in the middle bays due to high loads and eight plies for the remaining bays. A full-scale static test of the FRTP skins attached to production spar box was conducted. The test was successful in demonstrating the static strength of the FRTP skins. The vertical spar box assembly with the FRTP skins had a net weight saving of 16.5 percent. Author

A90-28231

UCAR 2040, A NOVEL WEAR RESISTANT COATING FOR AIRCRAFT STRUCTURAL COMPONENTS

JOHN M. QUETS (Union Carbide Coatings Service Corp., Indianapolis, IN) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 1047-1054. refs

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Recently, Union Carbide Coatings Service Corporation developed a new detonation gun, and from it, a new generation of wear resistant coatings. This new gun, the Super D-Gun, was designed to obtain ultrahigh particle velocities. Consequently, it produces coatings with performance characteristics previously unattainable. These new coatings, the UCAR(R) 2000 Series, offer an improved resistance to wear with little or no effect on the fatigue performance of the component substrate. One Super D-Gun coating in particular, UCAR 2040, was designed specifically for these fatigue sensitive components in the aircraft industry that also require a superior resistance to wear. The effect of UCAR 2040 on the fatigue performance of the substrate was evaluated for four different alloys - Ti-6-4, Ti-8-1-1, 4340 steel and 7075-T73 aluminum. UCAR 2040 has only a minimal effect on the fatigue performance of the titanium alloys, and no effect or even a positive effect on the fatigue performance of the steel and aluminum alloys. Author

A90-29275#
DESIGN AND FABRICATION OF A PROTOTYPE RESIN MATRIX COMPOSITE INTERCEPTOR STRUCTURE
G. D. WONACOTT, K. J. CHEVERTON, J. D. BAILEY (SPARTA, Inc., San Diego, CA), and JOHN E. MARKS (Composite Optics, Inc., San Diego, CA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 500-515. Research supported by the U.S. Army.
(AIAA PAPER 90-1004)

An account is given of the design, analysis, and fabrication of a high performance, graphite fiber-reinforced high-temperature bismaleimide-matrix composite material system for an SDI-related exoatmospheric kinetic-kill interceptor missile warhead. Heat fluxes encountered during acceleration to Mach 15-20 drives the design identification of high-temperature resin systems with the requisite mechanical properties. The 27-lb structural weight of a geometrically identical structure fabricated from a carbon fiber-reinforced epoxy-matrix system is shown to be reducible to 12.8 lb through the use of the present bismaleimide-matrix material. A comparison is made of this polymer matrix system with a metal-matrix composite structure fabricated to the same design requirements. O.C.

A90-29492#
AGING AND ANTIOXIDANT SURVEILLANCE STUDIES ON TURBINE FUEL JP-5 AND JP-10
DAU-GWEI HWANG, TSAN-ZONG HONG, and CHIA-PIN TANG (Chung Shan Institute of Science and Technology, Lung-Tan, Republic of China) IN: Environmental testing in the 90's; Proceedings of the Twentieth International ICT Annual Conference and Eighteenth GUS Annual Technical Meeting, Karlsruhe, Federal Republic of Germany, June 27-30, 1989. Pfinztal, Federal Republic of Germany, Fraunhofer-Institut fuer Chemische Technologie, 1989, p. 66-1 to 66-14. refs

It is noted that JP-5 and JP-10 are important propulsion fuels of rocket systems due to their stability and high energy content. Thus, it is important to search for additives to prolong the storage stability and to determine the effectiveness of these additives. In this paper, results obtained from UV absorption measurement of gum formation and peroxide build-up indicate that: (1) the total UV absorbance at 337 nm was proportional to the gum formation in JP-5, (2) the rate of gum formation was constant when the antioxidant was used up at a given temperature, (3) the logarithm of the peroxide number was proportional to the storage time, (4) when the storage temperature was decreased by 10 C the storage time was increased by a factor of 2.58, and (5) 2.6-Di-t-butyl-4-methylphenol was the most effective antioxidant in JP-5 and JP-10. R.E.P.

A90-29638
SEALING THE FUTURE
MADHU BAILE and SCOTT E. FUSON (Dow Corning Corp., Midland, MI) Aerospace Composites and Materials (ISSN 0954-5832), vol. 2, Mar.-Apr. 1990, p. 14-17.
Copyright

A development status and performance capabilities evaluation is presented for sealants and adhesives currently used by military aircraft subject to great variations in operating temperatures and weather conditions over a range of operational regimes. Sealants are frequently of fluorosilicone type, which is resistant to fuel, oils, and solvents at the temperatures associated with fuel tankage in military aircraft. Adhesive systems prominently include a silicone interlayer which bonds the substrates used in canopies and periscopes, while precluding the delamination problems that occur with rapid temperature cycling. Such silicone compounds are transparent to the UV component of sunlight, and accordingly exhibit excellent weathering properties. O.C.

A90-29643
NATURAL HONEYCOMB
FRANK COLUCCI Aerospace Composites and Materials (ISSN 0954-5832), vol. 2, Mar.-Apr. 1990, p. 44-46, 48.
Copyright

An evaluation is made of the comparative advantages of the use of balsa wood in the cores of sandwich panels for advanced composite airframe primary structures. A primary advantage of balsa is its low cost. The balsa core, whose wood grain is aligned perpendicular to the facings, is easily covered with sheet aluminum or either thermosetting or thermoplastic composite sheets, yielding panels with high peel strength and moisture absorption-resistance. Balsa cores can be selected which range from 6 to 16 lb/cu ft in density; grade is determined by the extent of cosmetic and mechanical imperfections. Compressive strengths vary from 945 to 3850 psi. O.C.

A90-29704* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
COMPOSITES BOOST 21ST-CENTURY AIRCRAFT ENGINES
JOSEPH R. STEPHENS (NASA, Lewis Research Center, Cleveland, OH) Advanced Materials and Processes (ISSN 0882-7958), vol. 137, April 1990, p. 35-38.
Copyright

Research and development in light-weight, high-temperature composite materials for ultrahigh-bypass engines to be used in high-speed civil transport/rotocraft is presented. It is noted that the expected benefits to be attained by this R&D include weight reduction, lowered fuel consumption, and lower direct operating costs. A major effort underway in this area is the Advanced High Temperature Engine Materials Technology Program (HITEMP) of NASA, which focuses on providing revolutionary high-temperature composite materials: to 425 C (800 F) for polymer-matrix composites (PMCs), to 1250 C (2280 F) for metal-matrix/intermetallic-matrix composites (MMCs/MCs), and to as high as 1650 C (3000 F) for ceramic-matrix composites (CMCs). Analytical modeling is being used to investigate the structural behavior of these advanced materials in six distinct areas: micromechanics, deformation and damage, fatigue, fracture, trade-off studies, and load definition. It is concluded that the development of advanced materials such as high-temperature composites is highly dependent on the availability of high-temperature fibers. The wide range of fiber characteristics needed will require the development of more than one fiber. In general, a candidate fiber should have low density, high strength, high stiffness, a CTE matching the matrix, chemical compatibility with the matrix, environmental stability and appropriate fiber diameter. R.E.P.

A90-29707
CLEANER SUPERALLOYS VIA IMPROVED MELTING PRACTICES
C. H. WHITE, P. M. WILLIAMS, and M. MORLEY (Inco Alloys, Ltd., Hereford, England) Advanced Materials and Processes (ISSN 0882-7958), vol. 137, April 1990, p. 53-57.
Copyright

It is noted that melting practice has progressed from arc melting and air-induction melting to vacuum induction melting and refining and to currently used consumable-electrode remelting. The principal objectives of melting are to provide adequate deoxidation to ensure alloy cleanness and good workability, refine the metal to remove metalloid impurities, minimize nonmetallic contamination, obtain a homogeneous mixing of the constituent-alloy ingredients within specified limits, and cast into an ingot suitable for further processing. Additional details are provided for different types of consumable-electrode remelting processes such as vacuum arc remelting and electroslag remelting. The objectives of consumable-electrode remelting are to control segregation of alloying elements, remove inclusions, refine/remove harmful elements such as sulfur, control beneficial minor element additions such as magnesium, prevent further contamination, and produce sound ingots suitable for forging. Some future directions of further refinements in consumable-electrode remelting are then cited. R.E.P.

A90-29825
TOUGHENED THERMOSETS FOR DAMAGE TOLERANT CARBON FIBER REINFORCED COMPOSITES
H. G. RECKER (Narmco, Anaheim, CA), V. ALTSTAEDT, W. EBERLE, T. FOLDA, D. GERTH (BASF AG, Ludwigshafen, Federal Republic of Germany) et al. SAMPE Journal (ISSN 0091-1062), vol. 26, Mar.-Apr. 1990, p. 73-75, 77, 78. refs
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High damage tolerance, a key requirement for composites in primary structure aircraft applications, is strongly influenced by interlaminar crack propagation in laminates. Comparison of both mode I and mode II interlaminar fracture toughness and CAI strength for differently toughened epoxy systems provided a nearly linear correlation of G(IIC) and CAI on intermediate modulus carbon fibers. Based on fundamental investigations a new toughened epoxy system, RIGIDITE X5255-3, with well balanced overall properties was successfully developed. Some of the key features of RIGIDITE X5255-3 are high CAI strength (310 MPa), small damage area (520 sq mm), low moisture pick up (0.6 percent) and good compressive strength (1275 MPa at 82 C wet) combined with high short-beam shear strength and excellent solvent resistance. Author

A90-29881
TIME DEPENDENT EFFECTS ON HIGH TEMPERATURE LOW CYCLE FATIGUE AND FATIGUE CRACK PROPAGATION ON NICKEL BASE SUPERALLOYS
F. GABRIELLI, M. MARCHIONNI, and G. ONOFRIO (CNR, Istituto per la Tecnologia dei Materiali Metallici non Tradizionali, Cinisello Balsamo, Italy) IN: Advances in fatigue science and technology; Proceedings of the NATO Advanced Study Institute, Alvor, Portugal, Apr. 4-15, 1988. Dordrecht, Kluwer Academic Publishers, 1989, p. 961-972. refs
Copyright
Fatigue tests were conducted at high temperatures in air and in vacuum at different frequencies and strain rates in order to ascertain the influence of time-dependent processes on the high-temperature behavior of several Ni-base superalloys. It is found that fatigue resistance in air is substantially reduced by the increase in temperature and the decrease of either frequency or strain rate. In low cycle fatigue tests, surface crack initiation results are accelerated by oxidation to a degree that greatly reduces fatigue life; this effect is more marked at lower strain rates and is confirmed by vacuum tests where low cycle fatigue life increases and the influence of strain rate disappears. O.C.

A90-30479
COATINGS FOR HIGH TEMPERATURE CORROSION IN AERO AND INDUSTRIAL GAS TURBINES
P. C. PATNAIK (Hawker Siddeley Canada, Inc., Orenda Div., Toronto) IN: Surface modification technologies II; Proceedings of the Second International Conference, Chicago, IL, Sept. 26-28, 1988. Warrendale, PA, Minerals, Metals and Materials Society, 1989, p. 37-61. Research supported by DND. refs
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Various types of service induced damage observed in hot section components of both aircraft and industrial gas turbines are considered, covering blades and nozzle guide vanes. The current state of coating technology used for protection of these components is reviewed. It is noted that advanced coatings obtained by incorporating Pt and Cr in the diffusion aluminides provide better resistance to environmental attacks in aircraft gas turbines, but they are limited by their thermomechanical fatigue properties. Good corrosion resistance and improved ductility are obtained by either an EB-PVD procedure or by a LPPS process. Industrial gas turbine components show little oxidation or intergranular attack, but suffer hot corrosion damage. Overlay coatings of the MCrAlY type with or without the addition of other alloy elements show greater promise due to their better resistance to thermal fatigue cracking. V.T.

A90-31120#
DEVELOPMENT OF EROSION RESISTANT COATINGS FOR COMPRESSION AIRFOILS
P. LOWDEN, D. NAGY, S. HOLLIDAY, and A. AGUERO (Liburdi Engineering, Ltd., Hamilton, Canada) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 36, March 1990, p. 24-28. Research supported by the National Research Council of Canada. refs
Titanium nitride layers produced by reactive ion plating have been evaluated in bench scale erosion tests to determine their effectiveness as protective coatings for turbine engine compressor airfoils. Resistance to erosion was found to vary as a function of coating parameters. The results indicate that significant improvements in component erosion life could be achieved through the use of such coatings. Author

N90-18400# Turbomeca S.A. - Brevets Szydlowski, Bizanos (France).
DEFECTS IN MONOBLOCK CAST TURBINE WHEELS [LES DEFAUTS DANS LES ROUES DE TURBINE COULEES MONOBLOC]
D. FOURNIER *In* AGARD, AGARD/SMP Review: Damage Tolerance for Engine Structures. 2: Defects and Quantitative Materials Behaviour 11 p Aug. 1989 In FRENCH
Copyright Avail: NTIS HC A06/MF A01; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive
Results of a study of cast alloy turbine wheels (blisks) are presented. The alloy used in the experiments was the nickel-based superalloy MAR M 004. The metallurgical structure, microstructure, and mechanical properties of the alloy are briefly described. Approximately 5000 specimens were evaluated using various destructive and non-destructive techniques. Data showing the nature and frequency of defects are presented and discussed. Factors affecting the propagation of semi-elliptical cracks are also addressed. Transl. by M.G.

N90-18527# Construcciones Aeronauticas S.A., Madrid (Spain). Div. de Fabricacion Materiales Compuestos.
IMPACT OF COMPOSITES IN THE AEROSPACE INDUSTRY [IMPACTO DE LOS COMPOSITES EN LA INDUSTRIA AEROESPACIAL]
A. MARTIN-CARRILLO 17 Apr. 1989 16 p In SPANISH
(ETN-90-96231) Avail: NTIS HC A03/MF A01
The utilization of composites is described, including carbon glass, boron or Kevlar fibers in epoxy or phenolic matrices. The substitution of metals by composites in the American helicopter ACAP illustrates the weight saving, technological improvements, changes in manufacturing procedures and impact on the overall economic result introduced by composites utilization. ESA

N90-18601# Utah Univ., Salt Lake City. Dept. of Fuels Engineering.
PRODUCTION OF HIGH DENSITY AVIATION FUELS VIA NOVEL ZEOLITE CATALYST ROUTES Final Report, Dec. 1985 - May 1987
FRANCIS V. HANSON 23 Oct. 1989 484 p
(Contract F33615-85-C-2567; AF PROJ. 3048)
(AD-A216444; WRDC-TR-89-2097) Avail: NTIS HC A21/MF A03 CSCL 21/4
The production of high density aviation fuels from reliable, domestic fossil fuel sources is of considerable importance to the USAF. The production of high density aviation fuels can be achieved by a number of alternative process sequences, for example, shape selective cracking of normal paraffins from an appropriate boiling range fraction of a napthenic crude; saturation of an aromatic FCC cycle stock of the appropriate boiling range; saturation of an appropriate boiling range fraction from a hydrocracker recycle stream when the feed to the hydrotreater is aromatic in nature; synthesis of the appropriate boiling range aromatic species from oxygenates over crystalline aluminosilicates followed by hydrogenation of the aromatic species; and direct synthesis of the aromatic hydrocarbons from hydrogen and carbon monoxide

over crystalline aluminosilicate-supported metal catalysis followed by hydrogenation of the aromatic species. A research program is summarized which was aimed at developing catalyst and processing concepts for the production of high density aviation turbine fuels via novel zeolite catalyst routes. GRA

N90-19364# Materials Research Labs., Ascot Vale (Australia).
EFFECT OF TEMPERATURE ON THE STORAGE LIFE OF POLYSULFIDE AIRCRAFT SEALANTS
JOHN W. BARBER, PETER J. HANHELA, ROBERT H. E. HUANG, and D. BRENTON PAUL Aug. 1989 44 p
(MRL-TR-89-31; AR-005-730) Avail: NTIS HC A03/MF A01

The storage performances of a range of PR-1422, PR-1436G and PR-1750 two-part polysulfide aircraft sealants of A and B classes, packaged both in cans and Semkit form, were surveyed. The sealants were separately maintained at temperatures of -16 , 2, 13, and 25 C and changes in viscosity of the polymer base compound, cure rate, peel strength and application life were monitored over 26 months. Concurrent changes in thiol content of the liquid polymer in the base compound and concentrations of Mn(IV) or CR(VI) in the cure pastes were also determined. Variations in activity of cure pastes with time were assessed using LP-32 as a standard polymer and changes in polymer base compounds were monitored by measuring cure rate with laboratory prepared reference cure pastes. Low temperature storage extended storage life significantly. After maintenance at temperatures of 2 C and below, the canned sealants still performed satisfactorily after two to three years storage. Most materials were procured several months after manufacture and with reduction of acquisition time further extension of the low temperature storage life could be expected. No significant storage differences between PT-1750 and PR-1422 sealants or the A or B classes were noted. Author

N90-19387# Federal Aviation Administration, Atlantic City, NJ.
IN-FLIGHT EVALUATIONS OF TURBINE FUEL EXTENDERS Final Report
AUGUSTO M. FERRARA and CAROL REA Feb. 1990 37 p
(DOT/FAA/CT-89/33) Avail: NTIS HC A03/MF A01

Flight tests were conducted which evaluated the use of ethanol as a blending agent for aircraft turbine fuels. As part of this study, a Beech King Air 200 was modified to incorporate a cabin tank which contained ethanol, and the fuel system was modified to deliver the ethanol to the starboard engine. Ten percent ethanol was mixed with JP-4 in the project fuel line, just before entering the engine. The test was performed over a broad range of operating conditions, and key performance parameters were measured. The use of ethanol as a blending agent reduced the power available and resulted in an increase in fuel consumption. The increase in fuel consumption was greater than the decrease in energy density. When operating on the ethanol/JP-4 mixtures, the test pilots noted the test engine required more throttle (throttle stagger). No other operational problems were uncovered during the course of the flight tests. A pre- and post-test engine inspection revealed no fuel related damage. Author

12

ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

A90-27678
RELIABILITY EVALUATION SYSTEM FOR CERAMIC GAS TURBINE COMPONENTS
SEIICHI HAMADA and TETSUO TERAMAE (Tokyo Electric Power Co., Engineering Research Center, Chofu, Japan) Japan Society of Materials Science, Journal (ISSN 0514-5163), vol. 39, Jan. 1990, p. 76-81. In Japanese, with abstract in English. refs
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The reliability evaluation system for ceramic gas turbine components was developed. This system, termed 'GFICES', is based on the statistical strength theory using two-parameter Weibull distribution. Main functions of this system are fast fracture analysis, static fatigue analysis, dynamic fatigue analysis, and the evaluation of the effect of proof testing. In addition, several other functions such as application of bimodal Weibull theory and consideration of aging degradation of ceramic components are available. When applied to the first-stage ceramic bucket, this system has been found to be effective for the strength evaluation of ceramic structural components. Author

A90-27951
SMART STRUCTURES WITH NERVES OF GLASS
R. M. MEASURES (Toronto, University, Downsview, Canada) Progress in Aerospace Sciences (ISSN 0376-0421), vol. 26, no. 4, 1989, p. 289-351. Research supported by NSERC, Ontario Laser and Lightwave Research Centre, Institute for Space and Terrestrial Science, et al. refs
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A comprehensive presentation is made of the development status and prospective applications of fiber-optic sensor-incorporating 'smart structures', which will be capable of collecting component-integrity information through a 'nervous system' over the course of their service lives. During fabrication and assembly, the integral sensor networks would check for structural flaws or handling damage, thereby enhacing a manufacturer's quality control efforts. In service within aircraft structures, integral fiber-optic sensors could provide strain, displacement, and deformation data required for many control situations, allowing actuators to respond to gusts almost instantaneously. O.C.

A90-27992#
STOCHASTIC FLUTTER OF A PANEL SUBJECTED TO RANDOM IN-PLANE FORCES. I - TWO MODE INTERACTION
R. A. IBRAHIM, P. O. ORONO, and S. R. MADABOOSI (Wayne State University, Detroit, MI) AIAA Journal (ISSN 0001-1452), vol. 28, April 1990, p. 694-702. refs
(Contract AF-AFOSR-85-0008)
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The effect of random variation of in-plane load acting on panels in supersonic flow is examined. The analysis includes stochastic stability and response moments of linear and nonlinear panels. The response moment equations are generated by using the Fokker-Planck equation approach. The mean-square stability boundaries and response moments are determined as functions of the spectral density of in-plane loads, aerodynamic pressure, air-to-structure mass ratio, and structural damping ratios. The nonlinear response is estimated by using a cumulant-neglect scheme. For equal modal damping coefficients, it is found that the damping stabilizes the panel in the sense of mean square. However, a paradoxical effect of the damping is found only for unequal damping coefficients where the effect is nonbeneficial. This observation is identical to the well-known results pertaining to the deterministic theory of panel flutter. The nonlinear response statistics are obtained in the time domain, the steady-state reveals that the response process is strictly stationary. This feature is believed to be first known for coupled systems with stiffness nonlinearity and is contrary to the nonstationary response characteristics of dynamic systems with inertia nonlinearity. Author

A90-27999#
EFFECTS OF TURBULENCE MODEL CONSTANTS ON COMPUTATION OF CONFINED SWIRLING FLOWS
N. S. VLACHOS (Illinois, University, Urbana) and J. M. KHODADADI AIAA Journal (ISSN 0001-1452), vol. 28, April 1990, p. 750-752. Research supported by the University of Illinois. refs
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The SIMPLE turbulence model procedure of Patankar (1980) is presently used to systematically assess the applicability of the standard k-epsilon turbulence model and one of its variations to decaying swirl prediction in developing turbulent pipe-flow. It is found that the trends and extent of the decaying tangential velocity are well-predicted by the standard k-epsilon model; the modified turbulence model results in slower decay, but with no substantial improvement over the standard model. O.C.

A90-28006#
FAST ADAPTIVE GRID METHOD FOR COMPRESSIBLE FLOWS
YASUJI TSUBAKISHITA, TAKAO YOSHIKAWA (Osaka University, Japan), and TETSUYA KITAGAWA (Toshiba Corp., Tokyo, Japan) Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811), vol. 32, Feb. 1990, p. 217-227. refs

An adaptive grid method has been applied for compressible flow problems, e.g., underexpanded free jets and transonic flows about airfoils. The present improved control of grid distribution enhances computational efficiency. The additional computational time associated with the adaptive grid method is less than 10 percent of total CPU time, compared with the result without the adaptive grid. To improve the overall efficiency in the computing time, the present algorithm also includes the use of the second-order explicit MacCormack scheme with Jameson's (Jameson and Baker, 1983) artificial dissipation, together with the operator splitting procedure and the local time step technique. The computer code is very simple and fast. The computed results exhibit good agreement with the available experimental data. Author

A90-28135#
ANALYSIS AND PRACTICAL DESIGN OF CERAMIC-MATRIX COMPOSITE COMPONENTS [CALCUL ET CONCEPTION PRATIQUE DES PIECES EN COMPOSITES A MATRICE CERAMIQUE]
B. BROQUERE, E. GAUTRONNEAU, and M. LACOSTE (SEP, Saint-Medard-en-Jalles, France) IN: National Workshop on Composites, 6th, Paris, France, Oct. 11-13, 1988, Proceedings. Paris, Association pour les Materiaux Composites, 1988, p. 839-853. In French.

The thermomechanical properties, processing methods, and applications of CMCs are reviewed, and practical techniques for material selection and component design are demonstrated for the case of a turbine wheel. Data on commercial C-C, C-SiC, and SiC-SiC composites are presented in extensive graphs, and particular attention is given to time-temperature service-life curves, failure mechanisms, and their implications for CMC component sizing. In the design example, a bidirectional SiC-SiC material is selected; a linear-isotropic model is derived; and anisotropy and nonlinearity are introduced via an incremental iterative scheme. The wheel design is then further refined, and the CMC structure is modified by using circumferential and radial fibers. Room-temperature mechanical tests on CMC disks with orthogonal and circular reinforcement patterns show maximum rotation speeds of 51,000 and 60,000 rpm, respectively. T.K.

A90-28137* Florida Univ., Gainesville.
WAVE FORMATION ON A LIQUID LAYER FOR DE-ICING AIRPLANE WINGS
CHIA-SHUN YIH (Florida, University, Gainesville) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 212, March 1990, p. 41-53. Research supported by NASA. refs
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Wave formation on a thin liquid layer used for deicing aircraft wings is investigated by studying the stability of airflow over a liquid-coated flat plate at zero angle of incidence. The ratio of the viscosity of the liquid to that of air is very high (over 500,000), and the Reynolds number based on liquid depth and air viscosity is of the order of a few thousand. Under these circumstances the analysis gives two formulas, in closed form, for the growth rate and phase velocity of the waves in terms of the wavenumber and other relevant parameters. The expected wavenumber is that for which the growth rate is the maximum. The instability is one in which the viscosity difference between the two fluids (air and liquid) plays the dominant role, and is of the kind found by Yih (1967). Author

A90-28162
DIGITAL X-RAY INSPECTION
FRANCIS LITTLE (GE Aircraft Engines, Evendale, OH) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 169-174.
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The equipment and its performance involved in digital X-ray inspection of aircraft engine turbine blades and vanes using an X-ray Inspection Module (XIM) are examined. The inspection process is reviewed, and the major components of the XIM are listed and their operations are described, as is the data acquisition process. Data are presented on the performance of the XIM system, and the system verification is reported. C.D.

A90-28165
CARBON/EPOXY TOOLING EVALUATION AND USAGE
M. CIMBALISTA (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 191-194.
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The objective of this program is to determine, through in-house testing, how carbon/epoxy tooling materials react over numerous cycles at different elevated temperatures in the autoclaves and ovens. The evaluation was developed to analyze stability, longevity and surface quality of room temperature setting/260 F service and 350 F service autoclave curing preimpregnated carbon fabrics. With the ongoing creation of new materials, a knowledge of what is available and its limitations is necessary to perform the complex tasks in the industry. McDonnell Douglas Helicopter Company has completed the first evaluation of these materials. Three hundred (300) cycles were run on the autoclave curing carbon/epoxy prepregs and twenty-five (25) cycles on the room temperature setting/260 F service materials. All testing of the materials was accomplished without the aid of a support, to allow the laminates to flex through cycling. Author

A90-28187
DAMAGE TOLERANCE ANALYSIS AND TESTING OF A WELDED CLUSTER GEAR FOR THE MAIN TRANSMISSION OF THE ADVANCED ATTACK HELICOPTER
TONY SHEN and W. D. HARRIS (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 457-462.
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Linear elastic fracture mechanics principles were used in conjunction with a detailed stress analysis to establish acceptance criteria for nonpropagating flaws in transmission gearings of the Advanced Attack Helicopter. The results show that certain weld flaws would not propagate under maximum service loads as predicted by fracture mechanics calculations. Thorough metallurgical investigations verify the NDE findings. The damage tolerance approach is shown to be an effective, reliable tool in establishing acceptance criteria for transmission cluster gear weld flaws. C.D.

A90-28234
DESIGN AND ANALYSIS OF COMPOSITE STRUCTURES WITH MANUFACTURING FLAWS
CHRISTOS KASSAPOGLOU and JERRY HAMMER (Sikorsky Aircraft, Stratford, CT) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 1075-1082. refs
(Contract DAAK51-81-C-0017)
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A brief summary of the types and frequency of manufacturing defects in composite parts is presented. As an example of how these defects can be analyzed and their effect incorporated in the design procedure, the buckling load of internal elliptical delaminations in composite panels under combined in-plane loads is determined. The effect of various parameters such as loading configuration, delamination size, aspect ratio, and through-the-thickness location is examined and example design charts are constructed. The possibility of using the results to establish nondestructive inspection standards is discussed. Author

A90-28258
APPLICATION OF PIEZOELECTRIC FOILS IN EXPERIMENTAL AERODYNAMICS
W. NITSCHE, P. MIROW, and T. DOERFLER (Berlin, Technische Universitaet, Federal Republic of Germany) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 57-65. Research supported by BMFT and MBB GmbH. refs
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Basic aspects of the use of piezoelectric foils and multisensor piezo arrays in flow experiments are examined, surveying piezofoil applications in the field of experimental aerodynamics (wind-tunnel and free-flight tests of airfoils). Also reported is a more general investigation of unsteady surface forces on flow around bodies. It is concluded that the piezofoil technique is useful for flow experiments aiming at characterizing airfoil flows by means of sensing unsteady surface forces. Preliminary results of the application of array, raster, and matrix sensors for monitoring flow instabilities are very encouraging. I.E.

A90-28259
USE OF LIQUID CRYSTALS FOR QUALITATIVE AND QUANTITATIVE 2-D STUDIES OF TRANSITION AND SKIN FRICTION
L. GAUDET and T. G. GELL (Royal Aerospace Establishment, Bedford, England) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 66-81. refs
Copyright

The use of properties of liquid crystals in wind tunnels to visualize transition and to measure skin friction is described. The effectiveness of a transition band to trip the laminar boundary layer on a swept wing is demonstrated by the growth of turbulent wedges with Reynolds number. The ability of liquid crystals to reveal intricate surface flow structures is clearly shown by subtle changes of color on an unswept rectangular wing when subjected to the combined effects of transition, separation, reattachment, and a normal shock. The time response of liquid crystals to changes in shear stress is illustrated by the shock pattern on the model surface, which was seen to be oscillating. A method involving the digitization of the video image into its three component colors has the potential for measuring skin friction in great detail. This involves using relationships correlating the component colors with wavelength and shear stress with wavelength. I.E.

A90-28262
LIQUID CRYSTAL THERMOGRAPHY FOR AERODYNAMIC HEATING MEASUREMENTS IN SHORT DURATION HYPERSONIC FACILITIES
A. J. D. SMITH and D. R. J. BAXTER (Southampton, University, England) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 104-112. refs
Copyright

A method has been developed which applies liquid-crystal thermography to the measurement of surface heat flux in short-duration hypersonic facilities. Flat-plate thermographs are compared with Eckert's prediction of surface heat flux to provide a calibration which replaces the liquid-crystal static color calibration. This allows measurement of high surface heat flux, avoiding sources of error associated with the large temperature gradient through the liquid-crystal layer and its response time. In conjunction with this, a multisubstrate model construction has been used, which allows measurement of surface heat flux on complex configurations. The technique has been successfully applied over a wide range of model scales and test times. I.E.

A90-28263
AN OPTICAL ANGLE OF ATTACK SENSOR
T. KEVIN MCDEVITT and F. KEVIN OWEN (Complere, Inc., Palo Alto, CA) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 113-124.
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A major source of transonic and supersonic wind-tunnel test data uncertainty is due to angle of attack (alpha) measurement errors caused by unknown sting and balance deflections under load. A novel laser-based instrument has been developed to enable continuous time-dependent alpha measurements to be made without signal dropout. Detectors capable of 0.01-deg resolution over an 18-deg range and 0.03-deg resolution over a 44-deg range with time-dependent outputs of 60 Hz have been developed. This capability is sufficient to provide accurate real-time alpha information for correlation with model balance measurements during transport and fighter model testing. Proof-of-concept experiments, along with the results of recent measurements conducted at the NASA Ames 9 x 7-ft supersonic wind tunnel, are presented. Experiments were also conducted to determine the reliable range, sensitivity, and long-term stability of the instrument. I.E.

A90-28264
MODEL INCIDENCE MEASUREMENT USING THE SAAB ELOPTOPOS SYSTEM
P. H. FUIJKSCHOT (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 125-128.
Copyright

For measuring the angle of attack of models in the NLR transonic wind tunnel, a SAAB Eloptopos system was acquired. The system consists of two infrared light-emitting diodes mounted fore and aft in the fuselage of the model, two linear array CCD cameras, and special processors. The cameras are mounted on the sidewall of the wind tunnel and have a viewing angle of 60 deg in the vertical direction. Thanks to an individual calibration and a special optimizing algorithm the camera resolution is enhanced to 0.001 deg. At a viewing distance of 1 m the resulting resolution in angle of attack of the model is typically 0.0026 deg. The system is individually calibrated for each model under wind-off conditions, using an extremely accurate gravity-sensing inclinometer as a reference. This procedure ensures the required accuracy of 0.01 deg in angle of attack under wind-on conditions. I.E.

A90-28268* Old Dominion Univ., Norfolk, VA.
INFRARED IMAGING AND TUFTS STUDIES OF BOUNDARY LAYER FLOW REGIMES ON A NACA 0012 AIRFOIL
EHUD GARTENBERG, A. SIDNEY ROBERTS, JR., and GRIFFITH J. MCREE (Old Dominion University, Norfolk, VA) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 168-178. refs
(Contract NAG1-735)
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A study of boundary-layer flow regimes on a NACA 0012 airfoil from zero angle of attack up to separation is presented. The boundary-layer transition from the laminar to the turbulent regime and the onset of the separation were detected by surface thermography of the airfoil performed with an infrared imaging system. The findings were compared with observations of aluminum-foil tufts visible with the infrared imaging system. This arrangement allows the infrared imaging system to assume the dual role of flow regime detection through surface thermography and flow visualization through the observation of the aluminum-foil tufts. Ultimately the temperature history on an uncontaminated surface could provide an interpretation of the state of boundary-layer flow. Separation studies performed on the NACA 0012 airfoil showed that aluminum foil tufts can be observed with infrared imaging systems. I.E.

A90-28271
DESIGN OF A THREE DIMENSIONAL DOPPLER ANEMOMETER FOR T2 TRANSONIC WIND TUNNEL
S. PRUDHOMME and A. SERAUDIE (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 197-205. refs
Copyright

The design of a three-dimensional laser Doppler anemometer for the T2 wind tunnel is presented. This LDA can measure simultaneously and without disturbance the three instantaneous components of the velocity in a complex transonic flow. The design is an innovative one, including fiber optics and real-time signal processing using a digitized Fourier transform. These technologies have been tested and qualified. The complete system will allow systematic optical measurements for most experiments performed in the T2. I.E.

A90-28273
A SEMICONDUCTOR LASER-DOPPLER-ANEMOMETER FOR APPLICATIONS IN AERODYNAMIC RESEARCH
F. DURST, R. MUELLER, and A. NAQWI (Erlangen-Nuernberg, Universitaet, Erlangen, Federal Republic of Germany) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 215-225. refs
Copyright

A miniature LDA system based on a semiconductor laser and an avalanche photodiode has been developed for aerodynamic measurements during flight tests. This device consumes significantly less power than a conventional system and can easily be operated with the electrical power available in an aircraft during flight. It is very small in size and can be conveniently transported and mounted on an aircraft wing. Since the device is also less expensive than a conventional system, several units can be used simultaneously to cover a large volume of the flowfield. The LDA hardware is described, and a theory for predicting the measuring accuracy is presented and applied. The theoretical predictions have been experimentally verified. Measurements in boundary layers are presented to demonstrate that a well-optimized semiconductor LDA is as reliable as a conventional gas-laser/PMT LDA. I.E.

A90-28278* Macrodyne, Inc., Schenectady, NY.
DATABASE FOR LDV SIGNAL PROCESSOR PERFORMANCE ANALYSIS
GLENN D. BAKER, R. JAY MURPHY (Macrodyne, Inc., Clifton Park, NY), and JAMES F. MEYERS (NASA, Langley Research Center, Hampton, VA) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 291-297. refs
Copyright

A technique for the direct comparison of LDV signal processors is developed, based on the use of a data base of digitized signal bursts obtained from an LDV under various configurations. This data base can be used to evaluate the response of signal processors and processor algorithms to specific signal characteristics and not to generalized simplistic waveforms. Examples from such a data base are presented to illustrate the capabilities of the proposed method. This data base includes signal ensembles obtained with three laser power settings at two transmitted focal lengths. I.E.

A90-28279
A LASER FLUORESCENCE ANEMOMETER FOR WATER TUNNEL FLOWFIELD STUDIES
F. KEVIN OWEN (Complere, Inc., Palo Alto, CA) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 298-309. refs
Copyright

Successful proof-of-concept experiments were carried out using the laser fluorescence anemometer (LFA) in the NASA Ames-Dryden water tunnel. The instrument provides for flow visualization and the nonperturbing simultaneous measurement of instantaneous velocity and dye concentration in complex mixing flowfields. The instrument was used in experimental studies of vortex flowfields, designed to determine the mechanisms and feasibility of controlling vortex breakdown by introducing relatively low rates of jet blowing along the vortex core. Measurements show that the LFA can provide new insight into the structure, entrainment, and control of mixing vortical and shear layer flows. It is shown that vortex breakdown can be controlled and eliminated by relatively small amounts of jet blowing along the vortex axis. I.E.

A90-28283
INSTRUMENTATION REQUIREMENTS FOR LAMINAR FLOW RESEARCH IN THE NLR HIGH SPEED WIND TUNNEL HST
A. ELSENAAR, P. B. ROHNE, D. ROZENDAL, and R. POESTKOKE (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 365-373. refs
Copyright

It is noted that the testing of laminar flow airfoils and wings in wind tunnels imposes very stringent requirements on the wind tunnel and the measurement techniques. Starting from experience obtained in the high-speed tunnel (HST) of the NLR, typical aspects such as scale effects, flow quality, and model contamination are discussed. Different techniques of transition detection are reviewed, and it is concluded that the infrared technique in combination with continuous wake rake traverses provides the best opportunity for a detailed experimental analysis of a particular laminar flow design. Drag measurements by means of continuous wake rake traverses with electronically scanned pressure transducers provide the required detail for drag evaluation. The NLR HST fulfills these requirements for laminar flow testing in a cost-effective way. I.E.

A90-28284
AN AUTOMATED VORTICITY SURVEYING SYSTEM USING A ROTATING HOT-WIRE PROBE
RODNEY V. BARRETT (Bristol, University, England) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 374-384. refs
Copyright

A simple method is described whereby a standard X hot-wire probe is used to obtain both steady-flow streamwise vorticity and the mean-flow velocity components, flow angles, and turbulence data. The probe, with its measuring plane parallel to the probe axis, is rotated about this axis with a small eccentricity, so that the measuring plane is displaced slightly from the axis. Measurements are taken at 90-deg intervals to define the tangential velocity along the sides of a square in the plane perpendicular to the stream direction, from which vorticity is obtained directly. The rotating probe is combined with a two-axis traversing rig, and the entire system is controlled by a microprocessor. Results from flow surveys behind wing tips are shown to be in good agreement with measurements using a nonaligning five-hole yawmeter vorticity survey system. The advantages of the present method include the lower flow interference of the hot-wire probe and its faster response, which allows turbulence data to be obtained. I.E.

A90-28295*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A FATIGUE STUDY OF ELECTRICAL DISCHARGE MACHINE (EDM) STRAIN-GAGE BALANCE MATERIALS
RAY D. RHEW (NASA, Langley Research Center, Hampton, VA) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 477-487. refs

A fatigue study was undertaken to determine how much electrical-discharge-machine (EDM) processing affected the fatigue life of balance materials: EDM and regular milling-machine (MM) samples were compared. Simulation of a typical balance stress configuration was devised for the fatigue testing in order to obtain results more closely related to balance situations. The fatigue testing of the EDM and MM specimens has indicated that the EDM technique does indeed reduce the fatigue life of 15-5PH steel, the first balance material tested. This conclusion was based on comparisons of the specimen fatigue lives with theoretical and manufacturer's data. Hence the EDM surface effects are detrimental to the fatigue life of this balance material. I.E.

A90-28306*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
HIGH TEMPERATURE SKIN FRICTION MEASUREMENT
PING TCHENG, HARLAN K. HOLMES, and FRANK H. SUPPLEE, JR. (NASA, Langley Research Center, Hampton, VA) IN: ICIASF '89 - International Congress on Instrumentation in Aerospace Simulation Facilities, 13th, Goettingen, Federal Republic of Germany, Sept. 18-21, 1989, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 583-594.

Skin friction measurement in the NASA Langley hypersonic propulsion facility is described. The sensor configuration utilized an existing balance, modified to provide thermal isolation and an increased standoff distance. For test run times of about 20 sec and ambient-air cooling of the test section and balance, the modified balance performed satisfactorily, even when it was subjected to acoustic and structural vibration. The balance is an inertially balanced closed-loop servo system where the current to a moving-coil motor needed to restore or null the output from the position sensor is a measure of the force or skin friction tending to displace the moving element. The accuracy of the sensor is directly affected by the position sensor in the feedback loop, in this case a linear-variable differential transformer which has proven to be influenced by temperature gradients. I.E.

A90-28337
FROM A SOW'S EAR - QUANTITATIVE DIAGNOSTIC DESIGN REQUIREMENTS FROM ANECDOTAL REFERENCES
JOHN M. ANDERSON (General Electric Co., Automated Systems Dept., Burlington, MA) IN: AUTOTESTCON '89 - IEEE International Automatic Testing Conference, Philadelphia, PA, Sept. 25-28, 1989, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 195-200.
Copyright

The diagnostic performance of modern avionic systems is widely characterized using anecdotal descriptors. 'Forty percent of all failures are due to switch/connector problems' and 'fifty percent of all equipment removed retests okay' are examples. While they are numerous and bear undeniable elements of truth, it is argued that their imprecision and fragmentary nature impede ready absorption of the information they convey into the diagnostic design process. The author asserts that these descriptors, taken in total, constitute a valuable, timely diagnostic requirements analysis input. He identifies a methodology for exploiting them, provides examples of the anecdotal inputs, presents interim and final analytical results, and proposes an approach to embedding the results into a diagnostic concept. I.E.

A90-28343
INTELLIGENT BUILT-IN TEST AND STRESS MANAGEMENT
DALE W. RICHARDS and JAMES A. COLLINS (USAF, Rome Air Development Center, Griffiss AFB, NY) IN: AUTOTESTCON '89 - IEEE International Automatic Testing Conference, Philadelphia, PA, Sept. 25-28, 1989, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 261-266.
Copyright

The authors describe two areas of technology, time stress measurement devices (TSMDs) and smart built-in test (smart BIT), which offer a combined approach to meeting future BIT needs. With reference to TSMD, one or more microelectronic packages are being developed with the capability of providing programmable and environmental stress measurement and recording. Smart BIT is an enhancement to traditional functional BIT which utilizes artificial intelligence techniques to produce an integrated test methodology for increased BIT effectiveness and confidence levels. The implementation of these techniques in conjunction with comprehensive fault-logging of the BIT output, associated TSMD, data and smart BIT decision criteria provides a singular, integrated, and complete test and maintenance capability in support of the needs of two-level maintenance. The state of this research and development is described along with the effect of its implementation on the respective operational and maintenance communities. I.E.

A90-28825
ESHBACH'S HANDBOOK OF ENGINEERING FUNDAMENTALS /4TH EDITION/
BYRON D. TAPLEY, ED. (Texas, University, Austin) and THURMAN R. POSTON, ED. New York, Wiley-Interscience, 1990, 2072 p. No individual items are abstracted in this volume.
Copyright

Formulas, constants, design parameters for basic devices, and other information of practical use to engineers and scientists is compiled in handbook form. Sections are devoted to mathematical and physical units and standards; mathematics; the mechanics of rigid and deformable bodies; incompressible fluids; aeronautics; astronautics; automatic control; computer science; engineering thermodynamics and heat transfer; electromagnetics and circuits; electronics; light, radiation, and acoustics; chemistry; engineering economics; and the properties of materials. T.K.

A90-28994
A METHOD FOR RECALCULATING THE TEMPERATURE FIELDS OF AIRCRAFT STRUCTURES FOR DIFFERENT EXPERIMENTAL CONDITIONS [METODIKA PERESCHETA TEMPERATURNYKH POLEI AVIAKONSTRUKTSII PRI RAZLICHNYKH USLOVIIAKH PROVEDENIIA EKSPERIMENTA]
A. T. USOV and L. A. SHEVCHUK TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 1, 1989, p. 126-130. In Russian.
Copyright

Algorithms and a program are presented by means of which the temperatures of structural elements, measured under one set of conditions, can be recalculated for a different set of conditions. The recalculation algorithm involves solving, by an iteration method, a system of equations based on the approximation of the measured temperature by integral sums of the convolution integral type and then determining, in discrete form, the function of the system response to a single pulse of thermal loading. V.L.

A90-29001
APPROXIMATION OF FREQUENCY CHARACTERISTICS USING IDENTIFICATION WITH A COMPLEX MASS MATRIX [APPROKSIMATSIIA CHASTOTNYKH KHARAKTERISTIK NA OSNOVE IDENTIFIKATSII S KOMPLEKSNOI MATRITSEI MASS]

M. S. GALKIN and B. V. GRIGOR'EV TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 2, 1989, p. 45-52. In Russian.
Copyright

A mathematical model with complex mass and stiffness matrices is proposed. It is shown that the introduction of an additional parameter, the imaginary part of the generalized mass, makes it possible to describe the resonance characteristics near the resonance frequency with a higher accuracy than that obtainable by other known methods. Two methods of frequency characteristic approximation are compared with reference to full-scale test results for aircraft structures. V.L.

A90-29147

IMPACT OF MULTIGRID SMOOTHING ANALYSIS ON THREE-DIMENSIONAL POTENTIAL FLOW CALCULATIONS

A. J. VAN DER WEES (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: Copper Mountain Conference on Multigrid Methods, 4th, Copper Mountain, CO, Apr. 9-14, 1989, Proceedings. Philadelphia, PA, Society for Industrial and Applied Mathematics, 1989, p. 399-416. Research supported by the Nederlands Instituut voor Vliegtuigontwikkeling en Ruimtevaart. refs
Copyright

Results are presented from research in support of the development of a nonlinear multigrid method for three-dimensional transonic potential flow. The paper focuses on the smoothing analysis of the developed incomplete lower-upper strongly implicit procedure smoothing algorithm as applied to Laplacian-type problems on grids exhibiting a wide variety of grid aspect ratios and grid skewness. It is shown that truly high grid aspect ratios and severe grid skewness lead to deterioration of the smoothing property of the algorithm. Subsequently, it is demonstrated that this deteriorated smoothing property in case of high grid aspect ratios can effectively be remedied by using a multigrid method employing selective coarsening, whereas the deteriorated smoothing property in case of severe grids skewness can be remedied by applying underrelaxation in the smoothing algorithm. Computational results for transonic potential flow around transport aircraft type wings show that the above discussed remedies are indeed effective for such flows, where the governing partial differential equation is of elliptic or mixed elliptic/hyperbolic type, respectively. Author

A90-29226

AIAA/ASME/ASCE/AHS/ASC STRUCTURES, STRUCTURAL DYNAMICS AND MATERIALS CONFERENCE, 31ST, LONG BEACH, CA, APR. 2-4, 1990, TECHNICAL PAPERS. PART 1 - MATERIALS, ENGINEERING OPTIMIZATION AND DESIGN

Washington, DC, American Institute of Aeronautics and Astronautics, 1990, 586 p. For individual items see A90-29227 to A90-29282.
Copyright

This volume treats materials, engineering optimization, and design. Particular attention is given to materials behavior and characterization, aircraft design optimization, integrated control/structure optimization, optimization methods, component and subsystem design, and space structures design. Twenty-one additional papers from this conference are published in NASA-CP-3064. B.J.

A90-29276#

AN APPROACH FOR ANALYSIS AND DESIGN OF COMPOSITE ROTOR BLADES

GERALDO A. MOURA and RAMESH KOLAR (U.S. Naval Postgraduate School, Monterey, CA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 516-523. refs
(AIAA PAPER 90-1005)

The advent of tilt rotor technology asks for rotors that have different twist and rpm requirements in hover and in forward flight to optimize for operational conditions. In order to assess the capabilities to fulfill these requirements, this paper presents a mapping of twist angle variation as a function of rpm and laminate orientation. The rotor is modeled as a D-shaped spar using three shell surfaces. Six configurations are obtained by assuming a six-layer cross-ply laminate. This six-layer cross-ply laminate is chosen as it provides the necessary extension-twist coupling without a hygrothermally-induced twist that is highly undesirable. The couplings and trends in the models are visualized in carpet plots, one for each model, in an attempt to establish a method to answer the basic question of the magnitude of twist angle available due to a particular geometry, material, and load system. Author

A90-29286*# California Univ., Davis.

GENERALIZED TRANSITION FINITE-BOUNDARY ELEMENTS FOR HIGH SPEED FLIGHT STRUCTURES

NESRIN SARIGUL-KLIJN (California, University, Davis) and ONUR ODABAS (Ohio State University, Columbus) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 598-602. Research supported by NASA. refs
(AIAA PAPER 90-1105) Copyright

A new class of 'Generalized Transition Finite-Boundary Elements' formulation is presented to predict temperature and/or stress distribution of flight structures at high speeds. A tweleve-noded three-dimensional transition element and a variable degree of freedom eight-noded element are formulated. These elements are incorporated into the formulation of the heat transfer and structural analysis problems by utilizing a newly introduced 'material approximation functions' concept. Results obtained from limited examples compared with the solutions from analytical and other finite element analysis solution. Numerical examples presented illustrate the effectiveness of these elements. Author

A90-29340#

STOCHASTIC CRACK GROWTH ANALYSIS METHODOLOGIES FOR METALLIC STRUCTURES

J. N. YANG (George Washington University, Washington, DC) and S. D. MANNING (General Dynamics Corp., Fort Worth, TX) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1159-1167. refs
(AIAA PAPER 90-1015) Copyright

Stochastic crack growth analysis methodologies are proposed and evaluated for predicting the statistical crack growth damage accumulation in metallic structures. These new methodologies are well-suited for ensuring U.S. Air Force damage tolerance and/or durability requirements for metallic airframes. Other promising metallic airframe applications include reliability centered maintenance, risk analysis, risks and liabilities associated with a structural warranty and structural reliability-based designs. They can easily be implemented using deterministic crack growth analysis results and an estimate of the crack growth life dispersion. Two different stochastic crack growth approaches are proposed (i.e., 'general' and 'analytical'). The 'general' approach uses a numerically defined deterministic service crack growth curve directly. Whereas, the 'analytical' approach approximates the service crack growth curve with one or more compatible crack growth segments. Analytical predictions for both approaches are correlated with experimental test results. Good correlations are obtained for a wide range of crack sizes. Author

A90-29359

AIAA/ASME/ASCE/AHS/ASC STRUCTURES, STRUCTURAL DYNAMICS AND MATERIALS CONFERENCE, 31ST, LONG BEACH, CA, APR. 2-4, 1990, TECHNICAL PAPERS. PART 3 - STRUCTURAL DYNAMICS I

Washington, DC, American Institute of Aeronautics and Astronautics, 1990, 602 p. For individual items see A90-29360 to A90-29408.
Copyright

Papers are presented on the prediction of unsteady transonic flow around missile configurations; unsteady flow computation of oscillating flexible wings; time-domain simulations of a flexible wing in subsonic compressible flow; and a reduced-cost rational-function approximation for unsteady aerodynamics. Topics discussed include flutter, aeroelasticity, aeroservoelasticity, and acoustic radiation. Consideration is given to computational prediction of stall flutter in cascaded airfoils; aeroelastic analysis of helicopter rotor blades; aeroelastic problems in turbomachines; aeroelastic tailoring analysis; shock testing using rapid frequency sweep; and the application of distributed piezoelectric film sensors to space robotics. I.F.

A90-29372*# Old Dominion Univ., Norfolk, VA.
FINITE ELEMENT TWO-DIMENSIONAL PANEL FLUTTER AT HIGH SUPERSONIC SPEEDS AND ELEVATED TEMPERATURE
DAVID Y. XUE, CHUH MEI (Old Dominion University, Norfolk, VA), and CHARLES P. SHORE (NASA, Langley Research Center, Hampton, VA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1464-1475. refs
(Contract NAS1-18584)
(AIAA PAPER 90-0982) Copyright

A consistent finite element formulation for flutter of two-dimensional panels including effects of temperature variation along panel length is presented. The von Karman nonlinear strain-displacement relation is used to account for the large-deflections, and the quasi-steady first-order piston theory is employed for aerodynamic loading in the finite-element formulation. The panel flutter under combined thermal/aerodynamic loading can be separated into solving two problems in sequence. They are: (1) postbuckling deflection, stresses and buckling stability boundary, and (2) critical dynamic pressure and linear flutter boundary. The solution procedures in solving these problems are presented in detail. Finite element results of two-dimensional panels with uniform temperature change are compared with classic analytical solutions. Influence of nonuniform temperature distributions on critical buckling temperature, flutter deflection and stresses, and flutter boundary is also given. Author

A90-29373#
NONLINEAR STALL FLUTTER AND DIVERGENCE ANALYSIS OF CANTILEVERED GRAPHITE/EPOXY WINGS
PETER DUNN and JOHN DUGUNDJI (MIT, Cambridge, MA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1476-1488. refs
(Contract F49620-86-C-0066)
(AIAA PAPER 90-0983) Copyright

The nonlinear, stalled, aeroelastic behavior of rectangular, graphite/epoxy, cantilevered plates with varying amount of bending-torsion stiffness coupling and with NACA-0012 styrofoam airfoil shapes is investigated for low Reynolds number flow. The nonlinear, stalled ONERA aerodynamic model initially developed by Tran and Petot (1981) is compared against experimental, low Reynolds number, two-dimensional lift and moment hysteresis loops. The ONERA model indicates good agreement with these experimental lift hysteresis loops, but poorer agreement with the experimental moment hysteresis loops. Nonlinear flutter calculations are done by applying Fourier analysis to extract the harmonics from the ONERA-calculated, three-dimensional aerodynamics, then applying a harmonic balance method and a Newton-Raphson solver to the resulting nonlinear, Rayleigh-Ritz aeroelastic formulation. Test wings were constructed and subjected to wind tunnel tests for comparison against the developed analysis. Wind tunnel tests show good agreement between theory and experiment for static deflections; for linear flutter and divergence; and for nonlinear, torsional stall flutter and bending stall flutter limit cycles. The current nonlinear analysis shows a transition from divergence to bending stall flutter, which linear analyses are unable to predict. Author

A90-29379#
FLUTTER ANALYSIS OF COMPOSITE PANELS IN SUPERSONIC FLOW
IN LEE and MAENG-HYO CHO (Korea Advanced Institute of Science and Technology, Seoul, Republic of Korea) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1540-1550. refs
(AIAA PAPER 90-1180) Copyright

The flutter analysis of composite panels in supersonic flow has been performed by the finite element method based on the shear deformable theory. The computational results of the vibration and flutter analysis are obtained using a 9-node isoparametric, shear deformable plate element and agree well with the results given in the available references. Guyan reduction procedure and the normal mode method are used to reduce the computational time. Flutter boundaries have been obtained for both cross-ply and angle-ply composite plates. Also, the flutter analysis has been performed for both rectangular and trapezoidal plates with clamped edges. The plate aspect ratio, the flow direction and the fiber orientation affect greatly the flutter boundaries. Author

A90-29380*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
CONCURRENT PROCESSING ADAPTATION OF AEROELASTIC ANALYSIS OF PROPFANS
DURBHA V. MURTHY (NASA, Lewis Research Center, Cleveland; Toledo, University, OH) and DAVID C. JANETZKE (NASA, Lewis Research Center, Cleveland, OH) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1551-1559. refs
(AIAA PAPER 90-1036) Copyright

This paper reports on a study involving the adaptation of an advanced aeroelastic analysis program to run concurrently on a shared memory multiple processor computer. The program uses a three-dimensional compressible unsteady aerodynamic model and blade normal modes to calculate aeroelastic stability and response of propfan blades. The identification of the computational parallelism within the sequential code and the scheduling of the concurrent subtasks to minimize processor idle time are discussed. Processor idle time in the calculation of the unsteady aerodynamic coefficients was reduced by the simple strategy of appropriately ordering the computations. Speedup and efficiency results are presented for the calculation of the matched flutter point of an experimental propfan model. The results show that efficiencies above 70 percent can be obtained using the present implementation with 7 processors. The parallel computational strategy described here is also applicable to other aeroelastic analysis procedures based on parallel methods. Author

A90-29396#
THE EFFECT OF STRUCTURAL VARIATIONS ON THE DYNAMIC CHARACTERISTICS OF HELICOPTER ROTOR BLADES
J. C. FRIES (U.S. Army, Ballistics Research Laboratories, Aberdeen Proving Ground, MD) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1782-1804.
(AIAA PAPER 90-1161)

The variations in the physical properties of helicopter rotor blades cause changes in natural frequencies and modal characteristics. These changes in the properties alter the rotor blade's dynamic response to aerodynamic forcing, and results in the loss of structural integrity, changes in helicopter controllability, and in large unwanted vibration levels transmitted to the body of the aircraft. The effect of variations of rotor stiffnes, mass, cg, elastic axis, and spatial position on the rotor blade where these variations occur are investigated for blade torsion and vertical bending. The significance of the changes of rotor blade natural characteristics is related to the helicopter's rotor speed and multiples thereof, to the number of blades in the rotor, and to the aerodynamic forcing distribution shapes that can exist. Author

A90-29399#

STOCHASTIC FLUTTER OF A PANEL SUBJECTED TO RANDOM IN-PLANE FORCES. II - TWO AND THREE MODE NON-GAUSSIAN SOLUTIONS

R. A. IBRAHIM (Wayne State University, Detroit, MI) and P. O. ORONO IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1822-1831. Research supported by the Institute for Manufacturing Research. refs

(Contract AF-AFOSR-85-0008)

(AIAA PAPER 90-0986) Copyright

The analysis of part I is extended to include non-Gaussian solutions of two- and three-mode interactions of a simply supported panel exposed to supersonic gas flow. A first order quasisteady state aerodynamic piston theory is used to model the aerodynamic loading. The Fokker-Planck equation is used to derive a general moment equation for three modes. This equation is also used to study two-mode interaction. A cumulant-neglect closure is used by setting cumulants of fifth and sixth orders to zero. This first order non-Gassian closure is used to solve for the response statistics in terms of the air-to-plate mass ratio, aerodynamic pressure, modal damping, and in-plane random force spectral density. It is found that the non-Gaussian solution yields higher levels for the response statistics than those obtained by the Gaussian solution. The inclusion of more modes results in a reduction of the response levels and expands the stability region. Author

A90-29400#

THE PREDICTION AND MEASUREMENT OF THERMOACOUSTIC RESPONSE OF PLATE STRUCTURES

C. F. NG and K. R. WENTZ (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1832-1838. refs

(AIAA PAPER 90-0988)

Simplified procedures for analyses of thermal acoustic responses of aircraft structures are derived. Experimental results are obtained for an aluminum plate with combined radiant heating and base excitation. Important characteristics of the acoustic response of thermally buckled plates are concluded from the theoretical and experimental results. Author

A90-29429*# Old Dominion Univ., Norfolk, VA.

VIBRATIONS OF RECTANGULAR PLATES WITH MODERATELY LARGE INITIAL DEFLECTIONS AT ELEVATED TEMPERATURES USING FINITE ELEMENT METHOD

C. C. GRAY (Old Dominion University, Norfolk, VA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 2094-2100. refs

(Contract NAG1-838)

(AIAA PAPER 90-1125)

A finite-element formulation is developed for the free vibration of rectangular plates which are under the influence of moderately large stress-free initial deflections and large thermal deflections. The von Karman nonlinear strain-displacement relations are used to account for the thermal deflections. The plates are thin, isotropic, and Hookean in nature. The temperature imposed on the plate is assumed to be constant through the thickness of the plate. Uniform and sinusoidal temperature distributions are studied. The material properties of the plates are temperature-dependent due to the relatively high temperatures imposed on the plates. Author

A90-29654

LDA PROCESSOR TSI MODEL 1990 ANALOG INPUT MODULE RECONSTRUCTION

LADISLAV KLABOCH and MICHAL PTACNIK Zprava VZLU, no. Z-60, 1989, p. 1-13, 15. refs

Copyright

The reconstruction of the TSI model 1990 laser-Doppler anemometer (LDA) processor is discussed. Several analog input modules of LDA counter processors are described. The requirements of the input module reconstruction are defined and the processes of reconstructing the module are examined, including work on the photomultiplier, the coaxial attenuator, the amplifier, and the filters. Results are presented from tests of the amplitude-frequency characteristics of the reconstructed LDA processor. Consideration is given to possible applications for the processor, such as measuring the high Doppler frequencies in centrifugal aeronautical compressors and supersonic wind tunnels. R.B.

A90-29866

METHODOLOGY OF VARIABLE AMPLITUDE FATIGUE TESTS

W. SCHUETZ (Industrieanlagen-Betriebsgesellschaft mbH, Ottobrunn, Federal Republic of Germany) IN: Advances in fatigue science and technology; Proceedings of the NATO Advanced Study Institute, Alvor, Portugal, Apr. 4-15, 1988. Dordrecht, Kluwer Academic Publishers, 1989, p. 511-522. refs

Copyright

A detailed examination is presented of the character of, and the rationale for, the engineering decisions associated with the design of variable-amplitude fatigue life-prediction experiments. This decision-making procedure addresses measurements of the in-service stress-time history, the scatter of measured test spectra, the manipulation of these spectra, and the synthesis of the test spectrum as a basis for a realistic variable-amplitude test sequence. The safe fatigue life for high survival probabilities in actual components is ascertained on the basis of a statistically-derived safety factor which can be taken directly from variable-amplitude tests. O.C.

A90-29891

ELECTROCHROMIC AIRCRAFT WINDOWS

Aerospace Engineering (ISSN 0736-2536), vol. 10, April 1990, p. 23-25.

Copyright

An electrochromic device with an amorphous tungsten oxide thin film as the electrochromically active member is described along with a solid-state tungsten oxide model cell. Electrochromic switching in the solar range of the cell is analyzed and comparative solar performance with architectural samples is presented. A solid-state electrochromic transparency configuration with tungsten oxide film, copper grid, and coupled gas free half cell reactions is discussed. V.T.

A90-29893

COATING TURBINE ENGINE COMPONENTS

Aerospace Engineering (ISSN 0736-2536), vol. 10, April 1990, p. 35-38.

Copyright

A diamond jet spraying process producing an aluminum-silicon alloy/polyester abradable coating is described. The Taguchi statistical technique is used for developing coating parameters such as bond strength, hardness, and polyester content. The performance of a diamond jet spray system is compared to a plasma system, with regard to their coating properties and microstructures for an engine fan case application. V.T.

A90-29911#

GEAR VIBRATION CONTROL WITH VISCOELASTIC DAMPING MATERIAL IN AEROENGINE

XINGMIN REN, MING XU, and JIALIU GU (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 5, Jan. 1990, p. 48-52. In Chinese, with abstract in English. refs

A technique for determining the optimum damping material distribution for some particular modes of gear vibration has been developed. Damping work expressions have been set up by modal analysis, and the optimum damping material distribution has been obtained by calculating the individual mode of a structure. The proposed method takes into account the influence of loading frequency and the environment temperature and cuts down computer time. Experiments have been done for a gear model without and with the damping material. The results show that the response of the gear with the damping material has decreased and the damping ratios have increased. Author

A90-29977

VIRTUAL PRINCIPLES IN AIRCRAFT STRUCTURES. VOLUME 1 - ANALYSIS. VOLUME 2 - DESIGN, PLATES, FINITE ELEMENTS

B. E. GATEWOOD Dordrecht, Kluwer Academic Publishers, 1989, p. Vol. 1, 347 p.; vol. 2, 381 p. refs

Copyright

The application of virtual principles (VPs) to the analysis and design of aircraft structures is examined in a textbook for undergraduate engineering students. Chapters are devoted to the basic three-, two-, and one-dimensional equations in structural analysis; virtual displacement and force methods; VPs for pin-jointed trusses and simple beams; box-beam shear stresses and deflections; and shear lag in thin web structures. Consideration is given to allowable stresses in flight-vehicle materials, the analysis and design of joints and splices, the structural design of aircraft components and pressurized structures, approximate solutions using the VPs, the dynamics of simple beams, the plate equations, approximate matrix equations for plate finite elements, matrix structural analysis using finite elements, and composite materials. Diagrams, graphs, and sample problems for each chapter are provided. T.K.

A90-30115

MULTIPLE-POWER-PATH NONPLANETARY MAIN GEARBOX OF THE MI-26 HEAVY-LIFT TRANSPORT HELICOPTER

GENNADII SMIRNOV (Mil Design Bureau, Moscow, USSR) Vertiflite (ISSN 0042-4455), vol. 36, Mar.-Apr. 1990, p. 20-23.

Copyright

The VR-26 main gearbox, designed in 1974 by MIL Design Bureau for the Mi-26 helicopter, is described. It is designed as a modular three-stage, nonplanetary multiple-power-path gear train. It is emphasized that this is the first time in helicopter engineering that an ordinary involute gear train with such a high gear ratio (i 8.76) has been used in the last reduction stage. The advantages of a multiple-power-path design in comparison to a planetary design used previously, such as gearbox weight reduction and maximum efficiency due to the cooling demand reduction, are described. In addition, its feasibility for transmitting torque exceeding 300,000-400,000 kgf-m to the main rotor shaft is demonstrated. N.B.

A90-30268

OPTIMAL COMPUTER-AIDED DESIGN OF THE BLADING OF AXIAL-FLOW TURBINES [OPTIMAL'NOE AVTOMATIZIROVANNOE PROEKTIROVANIE PROTOCHNYKH CHASTEI OSEVYKH TURBIN]

FELIKS A. STOIANOV Kiev, Izdatel'stvo Naukova Dumka, 1989, 176 p. In Russian. refs

Copyright

The structures of mathematical models describing the configuration and operation of the blading of axial-flow turbines and used for evaluating their efficiency and reliability are reviewed. Based on these structures, a solution is presented to the problem of optimal computer-aided design of turbine blading. Results of specific studies are presented to demonstrate the high efficiency of the approaches proposed here. V.L.

A90-30706*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

THREE APPROACHES TO RELIABILITY ANALYSIS

DANIEL L. PALUMBO (NASA, Langley Research Center, Hampton, VA) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 308-315. refs

It is noted that current reliability analysis tools differ not only in their solution techniques, but also in their approach to model abstraction. The analyst must be satisfied with the constraints that are intrinsic to any combination of solution technique and model abstraction. To get a better idea of the nature of these constraints, three reliability analysis tools (HARP, ASSIST/SURE, and CAME) were used to model portions of the Integrated Airframe/Propulsion Control System architecture. When presented with the example problem, all three tools failed to produce correct results. In all cases, either the tool or the model had to be modified. It is suggested that most of the difficulty is rooted in the large model size and long computational times which are characteristic of Markov model solutions. I.E.

A90-30711

ELECTRIC CONTROLS FOR A HIGH-PERFORMANCE EHA USING AN INTERIOR PERMANENT MAGNET MOTOR DRIVE

T. M. JAHNS (General Electric Co., Schenectady, NY) and R. C. VAN NOCKER (General Electric Co., Aircraft Control Systems Dept., Binghampton, NY) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 346-354. refs

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A controller for a high-performance electrohydrostatic actuator (EHA) has been developed using an interior permanent magnet (IPM) synchronous motor to produce the servo motion. The buried-magnet design of the IPM motor yields a combination of desired characteristics including high efficiency, robust rotor construction, and wide operating speed range. Power converter size has been minimized by using insulated-gate bipolar transistor (IGBT) power switches combined with high-voltage integrated circuit (HVIC) gate drivers in phase-leg power modules. Experimental results for the demonstrator motor-controller hardware rated at 12 hp (continuous) are presented which confirm the attractive performance characteristics of the IPM motor drive. I.E.

A90-30779#

AIR FORCE MANUFACTURING TECHNOLOGY NDE PROGRAMS SUPPORTING MANUFACTURING AND MAINTENANCE

EDWARD WHEELER (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 4. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 1539-1545.

Department of Defense MANTECH (manufacturing technology) and REPTECH (repair technology) principles and objectives are stated. Attention is given to the following current MANTECH programs: retirement for cause/NDE (nondestructive evaluation), integrated bladed inspection system, in-service inspection system for composites, improved ultrasonic equipment (pulser/receiver), X-ray computed tomography, and advanced transducer production. The following past MANTECH NDE programs are also discussed: photogrammetry, eddy current disk inspection, capacitance hole probe, automated dimensional inspection, and inspection for cracks under fasteners. I.E.

A90-30791

A VERY HIGH SPEED SWITCHED-RELUCTANCE STARTER-GENERATOR FOR AIRCRAFT ENGINE APPLICATIONS

STEPHEN R. MACMINN (General Electric Co., Schenectady, NY) and WILLIAM D. JONES (GE Aircraft Engines, Lynn, MA) IN: NAECON 89; Proceedings of the IEEE National Aerospace and

Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 4. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 1758-1764.
Copyright

An electric direct-drive gearless starter-generator has been designed and built for an aircraft engine application. The system is based on a switched-reluctance motor, which was chosen for its simplicity, robustness, high-speed capability, and efficiency. The overall system configuration and the design of the switched-reluctance motor and its solid-state power converter are described. When operating as engine starter, the motor produces torque to spin the engine up to its light-off speed. Following light-off, the motor continues to produce torque to assist the engine in accelerating to idle speed. When the engine is running, the machine generates electrical power to supply engine and vehicle loads up to a peak operating speed of 50,000 rev/min. Key issues in the machine design are reliability, high speed, power density, and cost. Test results have verified that the system can meet the torque and generated-power requirements over its entire operating range. I.E.

A90-30813
MECHANICAL CONSIDERATIONS FOR RELIABLE INTERFACES IN NEXT GENERATION ELECTRONICS PACKAGING
JOHN K. HAGGE (Rockwell International Corp., Cedar Rapids, IA) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 4. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 2021-2026. refs
Copyright

The author reviews some basic mechanical design approaches available to assure reliable interfaces within and between packaging levels in the chip, package, and circuit-board assemblies. While the approaches can be applied to traditional circuit-board and hybrid assemblies emphasis is placed on the hybrid wafer-scale integration multichip module packaging technologies. It is concluded that a combination of recently available packaging materials of improved properties, recently developed improved analysis techniques, and the advantages of the new hybrid wafer-scale integration technology offers the opportunity to design significantly improved reliability into the next generation of military electronic equipment. Additionally, the equipment size and weight can be reduced significantly. A dramatic demonstration of the miniaturization possible with these technologies was made on a miniaturized version of a GPS (global positioning system) receiver. I.E.

A90-30819
MODULAR AVIONIC ARCHITECTURES
EDWARD TRUJILLO (Hughes Aircraft Co., El Segundo, CA) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 4. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 2080-2084.
Copyright

The author presents an analysis revealing some of the salient features of modular avionics. A decomposition of the modular avionics concept is performed, highlighting some of the key features of such architectures. Several layers of architecture can be found in such concepts, including those relating to software structure, communication, and supportability. Particular emphasis is placed on the layer relating to partitioning, which gives rise to those features of integration, modularity, and commonality. Where integration is the sharing of common tasks or items to gain efficiency and flexibility, modularity is the partitioning of a system into reconfigurable and maintainable items, and commonality is partitioning to maximize the use of identical items across the range of applications. Two architectures, MASA (Modular Avionics System Architecture) and Pave Pillar, are considered in particular. I.E.

A90-31028
LASER MACHINING DEVELOPMENTS AT MCDONNELL DOUGLAS
PETER L. R. HOFFMAN (McDonnell Aircraft Co., Saint Louis, MO) IN: Lasers '88; Proceedings of the International Conference, Lake Tahoe, NV, Dec. 4-9, 1988. McLean, VA, STS Press, 1989, p. 750-757.
Copyright

Activities underway at McDonnell Douglas are discussed which represent a good start toward the introduction of laser machining and welding into manufacturing facilities. These projects include laser trimming, welding, and scribing of aircraft components, missile components, and aircraft skins. The technological and economic pressures underlying these trends are reviewed. C.D.

A90-31117#
FRACTURE MECHANICS ASSESSMENT OF EB-WELDED BLISKED ROTORS
M. HONGOH and R. N. TADROS (Pratt and Whitney Canada, Longueuil) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 36, March 1990, p. 4-10. refs

The concept of Electron Beam (EB)-welded blisked axial compressor rotor has been successfully applied to Pratt and Whitney Canada's turbofan engine. Parts reduction accomplished by the concept is expected to contribute to the high reliability and durability of the engine. This paper focuses on fracture mechanics assessment of the EB-welded blisked compressor rotors. Through establishing quality standards, the results will be used to ensure structural integrity of the component. Also described is a design system for the EB-welded rotors based on Statistical Linear Elastic Fracture Mechanics (SLEFM). Author

N90-18609# European Space Agency, Paris (France).
MATERIALS AND STRUCTURES FOR 2000 AND BEYOND: AN ATTEMPTED FORECAST BY THE MATERIALS AND STRUCTURES DEPARTMENT OF THE DLR
CARL-JOCHEN WINTER, MARTIN MAILAENDER (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Stuttgart, Germany, F.R.), HEINRICH BERGMANN, HANS FOERSCHING, WOLFGANG BUNK, GERHARD GRUENINGER, and BERNDT FEUERBACHER Dec. 1989 83 p Transl. into ENGLISH of Werkstoffe und Bauweisen fuer 2000 und danach Ein Versuch des DLR-Forschungsbereichs Werkstoffe und Bauweisen (Stuttgart, Fed. Republic of Germany, DFVLR), Feb. 1989 p 1-82 Original language document was announced as N89-25358
(ESA-TT-1154; DFVLR-MITT-89-02; ETN-90-96218) Avail: NTIS HC A05/MF A01; original German version available from DFVLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne 90, Fed. Republic of Germany, 20.50 DM

The following forecasts were attempted on 21 to 22 Oct. 1988: to estimate what challenges the next 15 years might bring, and what would be the consequences for the direction and methodology of work, and for the organization of the institutes and of the research department. Building on the basis of the current position and of the discussions, the views of the five institutes, namely those for aeroelasticity, advanced design and manufacturing technology, space simulation, structural mechanics and materials research, on the future, are presented. A summary drawn up, and derived action guidelines, are given. ESA

N90-18670# Naval Postgraduate School, Monterey, CA.
AUTOMATION AND EXTENSION OF LDV (LASER-DOPPLER VELOCIMETRY) MEASUREMENTS OF OFF-DESIGN FLOW IN A SUBSONIC CASCADE WIND TUNNEL M.S. Thesis
KENNETH D. MURRAY Jun. 1989 147 p
(AD-A216627) Avail: NTIS HC A07/MF A01 CSCL 20/4

A two component Laser Doppler velocimetry system was successfully automated to speed the data acquisition and reduction process for flow measurements in a subsonic linear cascade wind tunnel. A three-axis traverse table was installed for computer controlled positioning of the LDV probe volume and a modification was made to permit measurements close to test blade surfaces. Commercial software was used for control and acquisition of the LDV data. Software was generated in-house to record tunnel conditions and to reduce and present the survey data. Detailed measurements were made of the flow through a controlled diffusion compressor cascade at an inlet flow angle of 48 degrees (8 degrees above design) to extend a database for viscous code validation. Test conditions were held nominally at M=0.25 and Rec=720000. The flow was shown to remain attached at the blade trailing edge but the measurements also indicated the presence of a less stable flow field in the blade passage when compared with previous observations at lower inlet flow angles. GRA

N90-18672# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.
ACTIVE STABILIZATION OF AEROMECHANICAL SYSTEMS Final Report, Sep. 1987 - Oct. 1989
J. DUGUNDJI, A. H. EPSTEIN, E. M. GREITZER, G. R. GUENETTE, and L. VALAVANI Dec. 1989 136 p
(Contract AF-AFOSR-0398-87; AF PROJ. 2307)
(AD-A216629; AFOSR-89-1878TR) Avail: NTIS HC A07/MF A01 CSCL 20/4

Three separate sections are included. The first is a brief review of the work done on active control of rotating stall. The second is on the existence of precursor travelling waves in compressor annuli and on some of the signal processing techniques used to examine such waves. The third section describes first-of-a-kind experiments in which tailored system structural properties were used to suppress compression system aerodynamic instability (surge). GRA

N90-18695# Institut de Mecanique des Fluides de Marseille (France). Equipe Mecanique des Fluides Numerique.
NUMERICAL INVESTIGATIONS OF HEAT TRANSFER AND FLOW RATES IN ROTATING CAVITIES. SIMULATION OF THE MOVEMENT GENERATED BY WALL TEMPERATURE GRADIENTS, BY SOURCE-SINK MASS FLOWS OR BY THE DIFFERENTIAL ROTATION OF THE WALLS, UNDER THE INFLUENCE OR CORIOLIS AND CENTRIFUGAL FORCES Final Report, Sep. 1987- Sep. 1988 [ETUDE NUMERIQUE DES TRANSFERTS THERMIQUES ET DES REGIMES D'ECOULEMENTS DANS LES CAVITES EN ROTATION. SIMULATION DES MOUVEMENTS GENERES PAR LES GRADIENTS DE TEMPERATURE PARIETAUX, PAR LES FLUX DE MASSE SOURCE-PUITS OU PAR UNE ROTATION DIFFERENTIELLE]
A. RANDRIAMAMPIANINA, A. CHAOUCHE, P. BONTOUX, G. P. EXTREMET, E. SEGURA, L. OUTTERS, J. P. FONTAINE, C. LONG, C. VAUGHAN, B. ROUX et al. 15 Feb. 1989 181 p In FRENCH
(Contract DRET-87-34-083-00-470-75-01)
(ETN-90-96253) Avail: NTIS HC A09/MF A01

The aim of the study is the simulation of a rotor-stator cavity model, reflecting real situations occurring in turbomachinery. The investigations performed on rotating disks systems are reviewed. The mathematical models and different numerical resolution methods are summarized. The results obtained in the case of rotating cavities, assuming the uniform rotation of the walls, are reported. The rotor-stator configurations, analyzed in the case of the differential rotation of the walls, are described. With regard to thermal effects, the density variation effects must be taken into account. ESA

N90-18697# European Space Agency, Paris (France).
CONTRIBUTION TO THE STUDY OF THREE-DIMENSIONAL SEPARATION IN TURBULENT INCOMPRESSIBLE FLOW
BRUNO CHANETZ (Office National d'Etudes et de Recherches Aerospatiales, Paris, France) Jan. 1990 171 p Transl. into ENGLISH of Contribution a l'Etude du Decollement Tridimensionnel en Ecoulement Turbulent Incompressible (Paris, France, ONERA), 1988 Original language document was announced as N89-29723
(ESA-TT-1169; ONERA-NT-1988-6; ETN-90-96331) Avail: NTIS HC A08/MF A01

An ellipsoid cylinder of revolution model consisting of half an ellipsoid with a cylindrical extension is considered. Pressure measurements at the wall made it possible to obtain a precise description of wall flow for a wide range of velocities (from 10 to 90 m/s) and angles of attack (from 0 to 40 deg). Oil-streak patterns were used for visualization of separation and transition lines. A discussion on the topology of flow patterns based on the experimental data and the work of Legendre is given. An oblate ellipsoid cylinder model whose front section is half an oblate ellipsoid and whose rear section is a cylindrical extension is considered. The surrounding flow for fixed velocity (50 m/s) and angle of attack (30 deg), was investigated with a 5-hole pressure probe and a three-direction laser Doppler velocimeter. Detailed information about the mean and turbulent values of the external field on the upper surface in the region where vortex structures originate and develop is derived. Pressure, velocity and vorticity fields reveal the vortex structure. The analysis based on mean values is completed by a detailed examination of results on turbulent flow. ESA

N90-18738# MRC Bearings-SKF Aerospace, Jamestown, NY.
LIFE OF CONCENTRATED CONTACTS IN THE MIXED EHD AND BOUNDARY FILM REGIMES Final Report
JOHN I. MCCOOL Aug. 1989 155 p
(Contract N00140-83-C-7149)
(AD-A216673; NAPC-PE-204C) Avail: NTIS HC A08/MF A01 CSCL 20/11

This analytical and experimental program investigates the influence of surface finish, material and lubricant on rolling contact bearings operating in the low or marginal lubricant film regime. The investigation includes failure analysis of field failures encountered with helicopter mast support and planetary gear transmission bearings, computer analysis of the above two bearing applications using SKF computer programs SHABERTH and PLANETSYS and testing of specimens made of M50 and 9310 steel using a geared roller tester at NAPC. GRA

N90-18743*# Boeing Helicopter Co., Philadelphia, PA.
CALCULATION OF FLIGHT VIBRATION LEVELS OF THE AH-1G HELICOPTER AND CORRELATION WITH EXISTING FLIGHT VIBRATION MEASUREMENTS Final Report
R. A. DITARANTO and V. SANKEWITSCH Nov. 1989 110 p
(Contract NAS1-17497)
(NASA-CR-181923; NAS 1.26:181923) Avail: NTIS HC A06/MF A01 CSCL 20/11

Boeing Helicopters, together with other U.S. Helicopter manufacturers, participated in a finite element applications program to give the United States a superior capability to utilize finite element analysis models in support of helicopter airframe design. The program was sponsored by the NASA Langley Research Center. Under this program, an activity was sponsored to evaluate existing analysis methods applicable to calculate coupled rotor-airframe vibrations. The helicopter used in this evaluation was the AH-1G helicopter. The results of the Boeing Helicopters efforts are summarized. The planned analytical procedure is reviewed. Changes to the planned procedure are discussed, and results of the correlation study are presented. Author

N90-18746*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FATIGUE CRACK INITIATION AND SMALL CRACK GROWTH IN SEVERAL AIRFRAME ALLOYS
M. H. SWAIN, J. C. NEWMAN, JR., E. P. PHILLIPS, and R. A. EVERETT, JR. (Army Aerostructures Directorate, Hampton, VA.) Jan. 1990 8 p
(NASA-TM-102598; NAS 1.15:102598; AVSCOM-TM-90-B-001) Avail: NTIS HC A02/MF A01 CSCL 20/11

The growth of naturally-initiated small cracks under a variety of constant amplitude and variable amplitude load sequences is examined for several airframe materials: the conventional aluminum alloys, 2024-T3 and 7075-T6, the aluminum-lithium alloy, 2090-T8E41, and 4340 steel. Loading conditions investigated include constant amplitude loading at R = 0.5, 0, -1 and -2 and the variable amplitude sequences FALSTAFF, Mini-TWIST and FELIX/28. Crack growth was measured at the root of semicircular edge notches using acetate replicas. Crack growth rates are compared on a stress intensity factor basis, to those for large cracks to evaluate the extent of the small crack effect in each alloy. In addition, the various alloys are compared on a crack initiation and crack growth morphology basis. Author

N90-19472# Federal Aviation Administration, Atlantic City, NJ. Technical Center.
OPERATIONAL EVALUATION OF INITIAL DATA LINK AIR TRAFFIC CONTROL SERVICES, VOLUME 1 Final Report
NICHOLAS J. TALOTTA, CLARK SHINGLEDECKER, and MICHAEL REYNOLDS (Midwest Systems Research, Inc., Dayton, OH.) Feb. 1990 67 p
(DOT/FAA/CT-90/1-VOL-1) Avail: NTIS HC A04/MF A01
The results are detailed of an operational evaluation of initial data link air traffic control (ATC) services. The operational evaluation was conducted at the Federal Aviation Administration (FAA) Technical Center utilizing the data link test bed. Initial data link services were evaluated in order to identify service delivery methods which optimize controller acceptance, performance, and workload. Author

N90-19534* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
METHOD AND APPARATUS FOR DETECTING LAMINAR FLOW SEPARATION AND REATTACHMENT Patent
JOHN P. STACK, inventor (to NASA) and SIVARAMAKRISHNAN M. MANGALAM, inventor (to NASA) (Analytical Services and Materials, Inc., Hampton, VA.) 18 Jul. 1989 13 p Filed 7 Jun. 1988
(NASA-CASE-LAR-13952-1-SB; US-PATENT-4,848,153; US-PATENT-APPL-SN-203178; US-PATENT-CLASS-73-432.1)
Avail: US Patent and Trademark Office CSCL 20/4
The invention is a method and apparatus for detecting laminar flow separation and flow reattachment of a fluid stream by simultaneously sensing and comparing a plurality of output signals, each representing the dynamic shear stress at one of an equal number of sensors spaced along a straight line on the surface of an airfoil or the like that extends parallel to the fluid stream. The output signals are concurrently compared to detect the sensors across which a reversal in phase of said output signal occurs, said detected sensors being in the region of laminar separation or reattachment. The novelty in this invention is the discovery and use of the phase reversal phenomena to detect laminar separation and attachment of a fluid stream from any surface such as an airfoil supported therein.
Official Gazette of the U.S. Patent and Trademark Office

N90-19542# Karlsruhe Univ. (Germany, F.R.). Inst. fuer Hydrologie und Wasserwirtschaft.
WIND TUNNEL DESIGN OF HEAT ISLAND TURBULENT BOUNDARY LAYER Ph.D. Thesis
[WINDKANALMODELLIERUNG VON WAERMEINSELN IN TURBULENTER GRENZSCHICHT]
BERNHARD BLOECHL 1988 159 p In GERMAN
(IHW-ET/50; ETN-90-95372) Avail: NTIS HC A08/MF A01
The design and physical and mechanical properties of a wind tunnel for the examination of heat islands are presented. City climatology elements, where heat adsorption and radiation and carbon dioxide emission are too high and dangerous are considered. Measurements and calculations are based principally on Reynolds number variations. The heat transfer is described by Stantom number. The Navier-Stokes equations for a compressible gas of constant viscosity in steady state are employed. After comparison to some city meteorology data, it is established that such a model of an atmospheric turbulent boundary layer is, predictably, impossible in water. Modified Nusselt number and temperature diagrams are easy to use with the proposed parameterization for all experimental conditions. ESA

N90-19543# National Aerospace Lab., Amsterdam (Netherlands). Informatics Div.
FLOW SIMULATION FOR AIRCRAFT
W. LOEVE and J. VANDERVOOREN 22 Dec. 1987 44 p In DUTCH; ENGLISH summary
(NLR-MP-87082-U; ETN-90-95413) Avail: NTIS HC A03/MF A01
The various aspects of computer simulation of flow about aircrafts, and their role in aircraft design are discussed. The general tendency in the industrial development process to accelerate product innovation by an integrated approach to the design is explained. Experimental wind tunnel investigations and mathematical modeling are discussed as the two available methods for the analysis of flow about aircrafts. The various flow models used in flow simulation are discussed in successive order of decreasing complexity, and their applicability is outlined. The successive steps in flow simulation are presented. The state of the art in relation to computer technology is described. Information aspects of simulation are discussed in general terms. ESA

N90-19609 Salford Univ. (England).
AN EXPERIMENTAL STUDY OF THE AEROELASTIC BEHAVIOUR OF TWO PARALLEL INTERFERING CIRCULAR CYLINDERS Ph.D. Thesis
EDUARDO BAUZER MEDEIROS 1988 316 p
Avail: Univ. Microfilms Order No. BRD-84966
Considered here is an experimental study of the flow-induced oscillations of two parallel interfering circular cylinders, the associated flow-induced excitations and the suppression of the resulting oscillations by increasing the damping. All three arrangements are discussed, namely: tandem, side-by-side and staggered with respect to the approaching fluid flow. The ratio-of-diameters of the two cylinders employed is 1:1, 1:2 and 2:1. The study describes the observed excitations for a wide range of reduced velocities Vr, relative transverse and streamwise spacings between the cylinders, L/D and T/D, and the damping expressed by the Scruton number Sc. The latter is varied by means of an eddy-current damping system, which stimulates the variation of structural damping of a structure. The main objective of the experiments is to relate the Scruton number, the reduced velocity and the relative spacings to the response of the two cylinders. Particular emphasis is put on the determination of the critical reduced velocity Vrc on the threshold of instability and the associated Scruton number Sc. The experimental program and the experimental apparatus are described in detail, including a discussion of the philosophy used when designing the test rig.
Dissert. Abstr.

13

GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

A90-28582
THE MICROPHYSICAL STRUCTURE OF SEVERE DOWNDRAFTS FROM RADAR AND AIRCRAFT OBSERVATIONS IN CINDE
ALFRED R. RODI (Wyoming, University, Laramie) and J. C. FRANKHAUSER (NCAR, Boulder, CO) IN: Conference on Radar Meteorology, 24th, Tallahassee, FL, Mar. 27-31, 1989, Preprints. Boston, MA, American Meteorological Society, 1989, p. 21-24. refs
(Contract NSF ATM-87-02993)
Copyright
The role of precipitation evaporation in the initiation and maintenance of downdrafts is investigated. The kinematic and thermodynamic structure of microburst downdrafts in the Convective Initiation and Downburst Experiment (CINDE) of 1987 is studied. Air motion, temperature, and moisture measurements collected by aircraft and radar on July 9, 1987 are analyzed. It is determined that downdraft velocity increases downward as the

reflectivity decreases indicating that evaporation effects are dominant in the formation of downdrafts. I.F.

A90-28612
THE SOURCE REGION AND EVOLUTION OF A MICROBURST DOWNDRAFT
WILLIAM P. MAHONEY and KIMBERLY L. ELMORE (NCAR, Boulder, CO) IN: Conference on Radar Meteorology, 24th, Tallahassee, FL, Mar. 27-31, 1989, Preprints. Boston, MA, American Meteorological Society, 1989, p. 154-157. Research supported by NCAR and NSF. refs
(Contract DTFA01-82-Y-10513)
Copyright

The microburst-producing shower of July 17, 1987 near Denver, Colorado is studied using high-resolution dual-Doppler data from the Convection Initiation and Downburst Experiment. Wind field, reflectivity, convergence, and equivalent potential temperature are analyzed. It is observed that the microburst-generating cell developed in a weak vertical shear environment and as it evolved the updraft became more fragmented and was replaced by a downdraft that strengthened into a microburst. I.F.

A90-28613
MICROBURST PRECURSORS OBSERVED WITH DOPPLER RADAR
R. POTTS (Commonwealth of Australia Bureau of Meteorology, Research Centre, Melbourne) IN: Conference on Radar Meteorology, 24th, Tallahassee, FL, Mar. 27-31, 1989, Preprints. Boston, MA, American Meteorological Society, 1989, p. 158-162. refs
Copyright

The application of single Doppler radar to the observation of microburst precursor characteristics in moderate and high reflectivity convective cells is studied. The procedures for selecting and analyzing the data are discussed. The microburst event of July 24, 1987 and the null event of July 31, 1987 are analyzed in order to determine the significant features of each event. Particular attention is given to the radial divergence, reflectivity, and microburst development. It is observed that there is a slight correlation between the maximum reflectivity in a cell, the average radial convergence across the cell in the 2-3 km layer, and the development of a microburst. I.F.

A90-28617
RANGE OBSCURATION MITIGATION BY ADAPTIVE PRF SELECTION FOR THE TDWR SYSTEM
SANDRA C. CROCKER (MIT, Lexington, MA) IN: Conference on Radar Meteorology, 24th, Tallahassee, FL, Mar. 27-31, 1989, Preprints. Boston, MA, American Meteorological Society, 1989, p. 175-178. Research sponsored by FAA. refs
Copyright

An adaptive procedure for selecting the pulse repetition frequency (PRF) of a radar is described. This method is to reduce range contamination within the coverage area for a TDWR system. The PRF selection procedure provides two optimal PRF values; one for the radar during the collection of data for microburst identification and the second for the collection of data for gust front identification. The applicability of the procedure to the TDWR system is evaluated. Graphs of obscuration assessment are presented. It is observed that adaptive PRF selection reduce the potential for obscuration within coverage areas for S-band and C-band TDWR systems. I.F.

A90-28620
CONVERGENCE ALOFT AS A PRECURSOR TO MICROBURSTS
MICHAEL D. EILTS and SUSAN K. OAKLAND (NOAA, National Severe Storms Laboratory, Norman, OK) IN: Conference on Radar Meteorology, 24th, Tallahassee, FL, Mar. 27-31, 1989, Preprints. Boston, MA, American Meteorological Society, 1989, p. 190-193. refs
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The use of a convergence aloft microburst precursor for forecasting and detection of severe downbursts is examined. Single- and dual-Doppler radar data collected in Oklahoma during June 1986 and in Colorado are analyzed to identify the precursors to microburst events. Particular consideration is given to the relationship between the downdraft strength and the magnitude of the convergent radial velocity difference aloft. Time versus height profiles of radial divergence are presented. It is detected that the Oklahoma wet microbursts have proportionately stronger convergence aloft for the same strength of divergences near the surface than the Colorado dry microbursts. It is noted that convergence aloft associated with a descending reflectivity core is a precursor to microbursts and is applicable to forecasting. I.F.

A90-28625
MICROBURST DIVERGENCE DETECTION FOR TERMINAL DOPPLER WEATHER RADAR
MARK W. MERRITT (MIT, Lexington, MA) IN: Conference on Radar Meteorology, 24th, Tallahassee, FL, Mar. 27-31, 1989, Preprints. Boston, MA, American Meteorological Society, 1989, p. 220-223. Research sponsored by FAA. refs
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The Terminal Doppler Weather Radar (TDWR) system under development by the FAA will furnish users with algorithm-detected indications of such potentially hazardous meteorological phenomena as microburst windshear on the basis of radar measurements from both surface radar and scans aloft. While the surface scans identify the outflows typical of microbursts, the scans aloft provide information on the reflectivity and velocity patterns associated with the microburst phenomenon. Attention is given to the TDWR's critical function of surface divergence region detection, whose performance has been evaluated against a large set of microburst cases encompassing a real-time operational demonstration. O.C.

N90-19718*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SPANWISE MEASUREMENTS OF VERTICAL COMPONENTS OF ATMOSPHERIC TURBULENCE
ROBERT K. SLEEPER Washington Apr. 1990 67 p
(NASA-TP-2963; L-16550; NAS 1.60:2963) Avail: NTIS HC A04/MF A01 CSCL 04/2

Correlation and spectrum magnitude estimates are computed for vertical gust velocity measurements at the nose and wing tips of a NASA B-57B aircraft for six level flight, low speed and low altitude runs and are compared with those of the von Karman atmospheric turbulence model extended for spanwise relationships. The distance between the wing tips was 62.6 ft. Airspeeds ranged from about 330 to 400 ft/sec, heights above the ground ranged from near ground level to about 5250 ft. and gust velocity standard deviations ranged from 4.10 to 8.86 ft/sec. Integral scale lengths, determined by matching measured autocorrelation estimates with those of the model, ranged from 410 to 2050 ft. Digital signals derived from piezoelectric sensors provided continuous pressure and airspeed measurements. Some directional acceleration sensitivity of the sensors was eliminated by sensor orientation, and their performance was spectrally verified for the higher frequencies with supplemental onboard piezoresistive sensors. The model appeared to satisfactorily predict the trends of the measured cross-correlations and cross-spectrum magnitudes, particularly between the nose and wing tips. However, the measured magnitude estimates of the cross-spectra between the wing tips exceeded the predicted levels at the higher frequencies. Causes for the additional power across the wing tips were investigated. Vertical gust velocity components evaluated along and lateral to the flight path implied that the frozen-turbulence-field assumption is a suitable approximation. Author

15

MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

A90-27645
ROBUST CONTROLLER DESIGN USING NORMALIZED COPRIME FACTOR PLANT DESCRIPTIONS
DUNCAN C. MCFARLANE (BH Pacific Pty., Ltd., Melbourne Research Laboratories, Clayton, Australia) and KEITH GLOVER (Cambridge, University, England) Research supported by BH Pacific Pty., Ltd. Berlin and New York, Springer-Verlag (Lecture Notes in Control and Information Sciences. Volume 138), 1990, 218 p. refs
Copyright

Techniques for the design of robust feedback controllers are developed analytically and demonstrated. Both the nominal-model transfer function and the class of systems for which stabilization by the controller is guaranteed are represented using the coprime-factor approach of Vidyasagar (1985). Chapters are devoted to the mathematical foundations of robust stabilization, uncertain systems, normalized coprime-factor plant descriptions, reduced-order controller design, and a loop-shaping design procedure. Results from applications to (1) the attitude control of a flexible spacecraft, (2) the attitude control of a flexible space platform, and (3) the control of aircraft vertical-plane dynamics are presented in tables and graphs and discussed in detail. T.K.

A90-28184* Search Technology, Inc., Norcross, GA.
DESIGNERS AS USERS - DESIGN SUPPORTS BASED ON CREW SYSTEM DESIGN PRACTICES
WILLIAM J. CODY (Search Technology, Inc., Norcross, GA) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 423-435. Research supported by NASA. refs
(Contract F33615-86-C-0542; DAAD05-87-ML-584)
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The behavioral processes in aviation crew system design are theoretically discussed. Interviews with designers concerning actual design experiences were conducted in a structured manner, focusing on the nature of the design problem, the designers's tasks, how decisions governing the human operator's role are made, and how this decision making can be supported. Two taxonomies emerge, one of which summarizes the nature of the design problem and the second of which summarizes the tasks that designers perform toward solving the problem. Combining the taxonomies yields a design problem space that is used to classify existing forms of support. The results of this classification and the implications for needed supports are discussed. C.D.

A90-28310
AUTOTESTCON '89 - IEEE INTERNATIONAL AUTOMATIC TESTING CONFERENCE, PHILADELPHIA, PA, SEPT. 25-28, 1989, CONFERENCE RECORD
Conference sponsored by IEEE. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, 379 p. For individual items see A90-28311 to A90-28354.
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The present conference on systems-readiness technologies discusses topics in functional vs parametric testing, two-level maintenance (TLM) concept tradeoffs and their logistical implications, trends in the miniaturization of commercial instruments, the development status of vehicular technology permitting two-level maintenance, and ATE systems architectures. Also discussed are issues in software tool development and performance, embedded software systems, support equipment for TLM, advancements in modular instrumentation and systems, novel tools for test software, self-maintenance concepts, and vehicular applications of TLM. O.C.

A90-28321
TWO-LEVEL MAINTENANCE CONCEPT FOR ADVANCED AVIONICS ARCHITECTURES
KEVIN C. JUDGE (Unisys Corp., Blue Bell, PA) IN: AUTOTESTCON '89 - IEEE International Automatic Testing Conference, Philadelphia, PA, Sept. 25-28, 1989, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 75-79.
Copyright

The advanced avionic architecture for next-generation military aircraft will feature common signal- and data-processing modules. The common modules will incorporate VHSIC technology and feature extensive built-in-test (BIT) and error logging capabilities. These new technologies present an opportunity to eliminate the intermediate level of maintenance because self-diagnosed modules can be routed directly to the depot. The author describes a support philosophy which, through BIT capabilities and a factory/depot tester architecture, makes the two-level maintenance concept possible. He explains how to exploit the modules' ability to test themselves and the resultant effect on the support equipment requirements. He then discusses a MATE implementation of the depot tester and addresses issues such as hardware/software modularity, the selection of the controller and instrumentation, and the use of ATLAS versus Ada as the test program language. I.E.

A90-28323
THE INTEGRATED SUPPORT STATION (ISS) - A MODULAR ADA-BASED TEST SYSTEM TO SUPPORT AN/ALE-47 COUNTERMEASURE DISPENSER SYSTEM TESTING, EVALUATION, AND REPROGRAMMING
GEORGE J. VALENTINO (BDM International, Inc., Dayton, OH) IN: AUTOTESTCON '89 - IEEE International Automatic Testing Conference, Philadelphia, PA, Sept. 25-28, 1989, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 100-107.
(Contract F33657-88-C-0026)
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The AN/ALE-47 countermeasures dispenser system (CMDS) is designed to be adaptive to new threat and user requirements. This adaptability is accomplished through software reprogramming of the system's operational flight program (OFP). An AN/ALE-47 system-peculiar integrated support station is used to verify the hardware changes at the system, line replaceable unit, and circuit card level, and to develop, reprogram, and verify software changes for the OFP, associated firmware, the mission data generator, or the ISS itself. The design and current developmental status of the ISS are discussed in detail. I.E.

A90-28330
REASONING FROM UNCERTAIN DATA - A BIT ENHANCEMENT
LAURENCE J. COOPER (SIGMAX, New Freedom, PA) and DENNIS E. SMITH (Desmatics, Inc., State College, PA) IN: AUTOTESTCON '89 - IEEE International Automatic Testing Conference, Philadelphia, PA, Sept. 25-28, 1989, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 146-149.
Copyright

It is proposed that artificial intelligence (AI) principles, coupled with powerful Bayesian statistical inference techniques, can be successfully applied to built-in-test (BIT) technology and can significantly contribute to the improvement of avionics BIT diagnostic capabilities. The goal is to extract more information from available data provided by the BIT, rather than to expand its testing capabilities. The proposed approach is illustrated by a TACAN (tactical air navigation) example. I.E.

A90-28342
A TEST AND MAINTENANCE ARCHITECTURE DEMONSTRATED ON SEM-E MODULES FOR FIBER OPTIC NETWORKS
CURTIS A. JENSEN and JACK H. CORLEY (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IN: AUTOTESTCON '89 - IEEE International Automatic Testing Conference, Philadelphia, PA, Sept. 25-28, 1989, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 255-260.
Copyright

The authors describe a general-purpose test and maintenance architecture for electronic subsystems and its demonstration in several avionics SEM-E modules for fiber-optic networking of the Advanced Tactical Fighter, A-12, and other modern aircraft. The results of applying this test and maintenance architecture are delineated in terms of payoff, penalty, and problems encountered. Industry efforts needed to eliminate some of the problems encountered are discussed. I.E.

A90-28829
TELEMETRY SYSTEMS OF THE FUTURE
WILLIAM D. RAUCH (Computer Sciences Corp., Lompoc, CA) IN: ITC/USA/'89; Proceedings of the International Telemetering Conference, San Diego, CA, Oct. 30-Nov. 2, 1989. Research Triangle Park, NC, Instrument Society of America, 1989, p. 63-73.
Copyright

The next 25 years will bring about a revolution in telemetry acquisition and processing. Airborne systems will become smaller and faster, providing additional monitoring and processing capabilities to test vehicles. In addition, ultrahigh-speed onboard data networks will provide communications between data-collection and processing units. Telemetry platforms will be required to collect the entire contents of the data network, in a manner similar to today's MIL-STD 1553 technology. The ground station will be required to process this bus information and provide it to the users for analysis. Ground-station components, including intelligent front-ends and host processors, could easily be replaced by a combination of onboard communication-network processors (similar to the current 1553 processors) linked to a ground-system data network. Processing could be shifted to the vehicle, while ground functions would remain dedicated to recording and analysis. Author

A90-28852
VERY-HIGH-PERFORMANCE DATA ACQUISITION/ANALYSIS/DISPLAY/CONTROL SYSTEMS BASED ON THE APTEC I/O COMPUTER
STRETHER SMITH, ERIC OLSON, DAVID MILLER, WILLIAM HOLLOWELL, and MICHELLE HORNAK (Lockheed Research Laboratories, Palo Alto, CA) IN: ITC/USA/'89; Proceedings of the International Telemetering Conference, San Diego, CA, Oct. 30-Nov. 2, 1989. Research Triangle Park, NC, Instrument Society of America, 1989, p. 345-359.
Copyright

The design and performance of the current APTEC I/O computer based systems are reviewed, and the near-term extensions of the technology are examined. The discussion covers real time displays of structural deflection, closed loop control systems (for structural-dynamic and acoustic testing and control-structure-interaction research), and extensions to an aggregate rate of 20,000,000 samples/sec at high accuracy. In addition to structural-dynamic testing, the systems are particularly suitable for wind-tunnel research and scram engine performance analysis. V.L.

A90-28860
REAL-TIME TEST DATA PROCESSING SYSTEM
ALLAN P. WHITE and RICHARD K. DEAN (Veda, Inc., Fort Walton Beach, FL) IN: ITC/USA/'89; Proceedings of the International Telemetering Conference, San Diego, CA, Oct. 30-Nov. 2, 1989. Research Triangle Park, NC, Instrument Society of America, 1989, p. 421-425.
Copyright

This paper examines the Test Data Processing System (TDPS) that provides the U.S. Army with the capability of meeting present and future real-time aircraft data processing requirements. TDPS also processes post test data from analog tape and allows engineers to monitor quick look data on both CRT and strip charts while the data are being processed in real-time or from analog tape. The Integrated Telemetry Analysis System (ITAS) preprocessor offers functional redundancy with the HP 1000 real-time computer. The ITAS is the hub of the TDPS. It accomplishes all the data preprocessing at extremely high rates and distributes the data to the other functional elements. It is concluded that as a turn-key system TDPS rivals the largest telemetry processing systems in terms of speed, capacity, and flexibility. R.E.P.

A90-29293*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A PARALLEL-VECTOR ALGORITHM FOR RAPID STRUCTURAL ANALYSIS ON HIGH-PERFORMANCE COMPUTERS
OLAF O. STORAASLI (NASA, Langley Research Center, Hampton, VA), DUC T. NGUYEN (Old Dominion University, Norfolk, VA), and TARUN K. AGARWAL IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 662-672. refs
(Contract NAG1-858)
(AIAA PAPER 90-1149) Copyright

A fast, accurate Choleski method for the solution of symmetric systems of linear equations is presented. This direct method is based on a variable-band storage scheme and takes advantage of column heights to reduce the number of operations in the Choleski factorization. The method employs parallel computation in the outermost DO-loop and vector computation via the 'loop unrolling' technique in the innermost DO-loop. The method avoids computations with zeros outside the column heights, and as an option, zeros inside the band. The close relationship between Choleski and Gauss elimination methods is examined. The minor changes required to convert the Choleski code to a Gauss code to solve non-positive-definite symmetric systems of equations are identified. The results for two large-scale structural analyses performed on supercomputers, demonstrate the accuracy and speed of the method. Author

A90-29897
MASSIVELY PARALLEL COMPUTING
HARRY E. PLUMBLEE, JR. (Lockheed Aeronautical Systems Co., Marietta, GA) Lockheed Horizons (ISSN 0459-6773), Jan. 1990, p. 33-40.
Copyright

The architecture and performance of massively parallel computers and their applicability to aerospace problems are discussed with particular reference to results obtained with a parallel machine using 16,384 processors. The discussion focuses on work conducted in the field of computational fluid dynamics and electromagnetics. The cost/performance of a massively parallel computer is evaluated. V.L.

A90-30226
AAAIC '88 - AEROSPACE APPLICATIONS OF ARTIFICIAL INTELLIGENCE; PROCEEDINGS OF THE FOURTH ANNUAL CONFERENCE, DAYTON, OH, OCT. 25-27, 1988. VOLUMES 1 & 2
JAMES R. JOHNSON, ED. (Netrologic, Inc., San Diego, CA) Conference sponsored by Dayton Special Interest Group for Artificial Intelligence, Systems Research Laboratories, Inc., and Texas Instruments, Inc. Xenia, OH, Dayton SIGART, 1988, p. Vol. 1, 375 p.; vol. 2, 374 p. For individual items see A90-30227 to A90-30249.

Topics presented include integrating neural networks and expert systems, neural networks and signal processing, machine learning, cognition and avionics applications, artificial intelligence and man-machine interface issues, real time expert systems, artificial intelligence, and engineering applications. Also considered are advanced problem solving techniques, combinational optimization for scheduling and resource control, data fusion/sensor fusion, back propagation with momentum, shared weights and recurrency, automatic target recognition, cybernetics, optical neural networks. R.E.P.

A90-30230#
AUTOMATING ACQUISITION OF PLANS FOR AN INTELLIGENT ASSISTANT BY OBSERVING USER BEHAVIOR
KEITH R. LEVI, VALERIE L. SHALIN, and DAVID L. PERSCHBACHER (Honeywell Systems and Research Center, Minneapolis, MN) IN: AAAIC '88 - Aerospace Applications of Artificial Intelligence; Proceedings of the Fourth Annual Conference, Dayton, OH, Oct. 25-27, 1988. Volume 1. Xenia, OH, Dayton SIGART, 1988, p. 120-132. refs
(Contract F33615-88-C-1739)

A critical requirement of intelligent automated assistants is a representation of actions and goals that is common to both the user and the automated assistant. Updating the intelligent system's knowledge base by observing user behavior is a convenient method for acquiring this common representation. An explanation based learning (EBL) system is being developed to automate the acquisition of new plans for a large pilot-aiding expert system. A preliminary planning/learning shell that is based on the TWEAK planning system of Chapman (1987) and DeJong and Mooney's (1986) EBL system. Author

A90-30236#
INTEGRATION OF INTELLIGENT AVIONICS SYSTEMS FOR CREW DECISION AIDING
K. J. KAISER, H. O. LIND, C. D. MEIER, R. O. STENERSON (Boeing Advanced Systems, Seattle, WA), S. ENAND (Boeing Advanced Technology Center, Seattle, WA) et al. IN: AAAIC '88 - Aerospace Applications of Artificial Intelligence; Proceedings of the Fourth Annual Conference, Dayton, OH, Oct. 25-27, 1988. Volume 1. Xenia, OH, Dayton SIGART, 1988, p. 230-241. refs

Artificial intelligence (AI) techniques offer the potential of increased mission effectiveness and reduced crew workloads through new approaches to automation and crew decision aiding. The kinds of systems that provide this support are often envisioned as a collection of cooperating intelligent systems which manage the crew display and voice channels, monitor the performance of on-board systems, maintain ready information about the flight environment, maintain consistent mission plans, and provide a facility for generating plans and modifying cockpit interactions. Integrating a collection of intelligent systems to achieve the functionality described raises fundamental questions about methods of communication and about how these systems will use information about similar domains at different levels of granularity. In this paper, an effort to integrate three prototypes, a Situation Assessor, a Hydraulics Diagnostic system, and a Cockpit Information Manager, are described. Author

A90-30249#
DUAL MODE RADAR FUSION BASED ON MORPHOLOGICAL PROCESSING
JAMES S. J. LEE and C. LIN (Boeing Electronics High Technology Center, Seattle, WA) IN: AAAIC '88 - Aerospace Applications of Artificial Intelligence; Proceedings of the Fourth Annual Conference, Dayton, OH, Oct. 25-27, 1988. Volume 2. Xenia, OH, Dayton SIGART, 1988, p. 350-361. refs

An information fusion scheme integrating ground truth maps with data from multiple polarimetric radar cross-sections, acquired by an active millimeter wave sensor is presented. Morphological processes detect terrain features such as roads and region boundaries in dual mode imagery, and combine the features of interest. Preliminary results have demonstrated the performance of this fusion scheme in detecting terrain features and estimating flight positions. Author

A90-30689#
ESTIMATION OF ATMOSPHERIC AND TRANSPONDER SURVEY ERRORS WITH A NAVIGATION KALMAN FILTER
JOSEPH K. SOLOMON and ZDZISLAW H. LEWANTOWICZ (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 140-147. refs

The Completely Integrated Reference Instrumentation System (CIRIS) is an aircraft inertial navigation system (INS) aided with range and range-rate measurements from precisely surveyed ground transponders. The full-ordered Kalman filter Åtruth' model for this system is developed with the goal of increasing the error-estimation accuracy of the CIRIS Kalman filter. The authors present the basic structure of the 127-state Åtruth' model Kalman filter. The random bias shaping filter model for the transponder position survey-errors and the first order Markov shaping filter model for the atmospheric propagation delays are developed. The full-ordered Kalman filter based on the CIRIS Åtruth' model is used to process empirical data from a CIRIS flight. The time histories of selected correlated measurement errors' means, covariances, and range residuals are plotted and analyzed with respect to the filter's estimate of position and velocity errors, as well as the aircraft trajectory. Finally, the initial conclusions drawn from these data are presented. I.E.

A90-30719* Royal Aerospace Establishment, Farnborough (England).
AN AMERICAN KNOWLEDGE BASE IN ENGLAND - ALTERNATE IMPLEMENTATIONS OF AN EXPERT SYSTEM FLIGHT STATUS MONITOR
G. F. BUTLER, A. T. GRAVES (Royal Aerospace Establishment, Farnborough, England), J. D. DISBROW (PRC System Services, Edwards, CA), and E. L. DUKE (NASA, Flight Research Center, Edwards, CA) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 428-434. refs
Copyright

A joint activity between the Dryden Flight Research Facility of the NASA Ames Research Center (Ames-Dryden) and the Royal Aerospace Establishment (RAE) on knowledge-based systems has been agreed. Under the agreement, a flight status monitor knowledge base developed at Ames-Dryden has been implemented using the real-time AI (artificial intelligence) toolkit MUSE, which was developed in the UK. Here, the background to the cooperation is described and the details of the flight status monitor and a prototype MUSE implementation are presented. It is noted that the capabilities of the expert-system flight status monitor to monitor data downlinked from the flight test aircraft and to generate information on the state and health of the system for the test engineers provides increased safety during flight testing of new systems. Furthermore, the expert-system flight status monitor provides the systems engineers with ready access to the large amount of information required to describe a complex aircraft system. I.E.

A90-30740
DATA BASE CORRELATION ISSUES
PATRICIA A. WIDDER, DANA PHILLIPS, and MAUREEN HRABAR (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 855-862.
Copyright

The present work is intended to serve as a tutorial on the basics of database correlation. It is noted that a full mission simulator consists of many different subsystems, each requiring a uniquely formatted data base. Although the format is different, the data in each must correlate with all other simulation subsystems (e.g., visual, sensor, and moving map). The simulation facility must also provide the capability of correlating each subsystem of one simulator with the comparable ones of other simulators. Correlation depends on several factors such as the simulation task, the computer image generators and graphics systems used, and the interaction of specific data-base components. The correlation components are described, and a specific correlation problem involving helicopters is addressed. I.E.

A90-30753
EXPERT SYSTEM - CONVENTIONAL PROCESSING INTERFACE
STEVE MARTZ and ERIC MUELLER (Boeing Military Airplanes, Wichita, KS) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 1020-1026.
Copyright

A cockpit information manager which utilizes expert-system technology requires a flexible, modular approach to interfacing the expert-system decision logic to the aircraft control and display functions. Existing cockpit display hardware dictates inflexible software control. To avoid this constraint, an interface must incorporate both the features of object-oriented design and the realities of device input/output. Past efforts in this direction are reviewed, and the Virtual Avionics Development System (VADS) and its interfaces (which meet the above requirements) are described. I.E.

A90-30754
AN ADAPTIVE-LEARNING EXPERT SYSTEM FOR MAINTENANCE DIAGNOSTICS
LUC P. TRAN and JOHN P. HANCOCK (McDonnell Aircraft Co., Saint Louis, MO) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 1034-1039.
Copyright

The Artificial Intelligence Applications to O-level Maintenance (AIATOM) expert system is the product of research into how AI experience-based learning can improve the accuracy and cost effectiveness of fault diagnosis in a military maintenance environment. AIATOM, an adaptive diagnostic maintenance advisor, was developed using LISP on a VAX system. AIATOM learns new symptoms and forms new associations between sets of known symptoms and maintenance actions. However, the system does not learn new maintenance actions. The current system has avionic and nonavionic knowledge bases. These knowledge bases are for the nose-wheel steering system and the stores-management system, respectively, of the U.S. Navy F/A-18 Hornet. These knowledge bases were implemented utilizing Navy maintenance technical orders and the expertise of maintenance personnel. The general capabilities of the user interface in AIATOM and the design of an adaptive-learning maintenance-assistant system are described. I.E.

A90-30757
METHODOLOGY FOR DEVELOPING AN ASSESSMENT EXPERT SYSTEM USING A PLANNING PARADIGM
PATRICIA L. DUTTON and RICHARD A. SMITH (Texas Instruments Artificial Intelligence Laboratory, Dallas) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 1053-1060. refs
Copyright

A methodology for developing an assessment expert system (AES) using a planning paradigm is described. An AES evaluates the information provided to it by the external environment and produces hypotheses of the current world state. In an AES application to commercial aircraft, an onboard sensor suite provides information concerning other airplanes within the aircraft's airspace, and a planning paradigm provides explicit control through its meta-assessment capability. A development methodology for an AES using this paradigm is discussed. It consists of the following steps: design the object hierarchy; design the internal interfaces; develop the assessment grammar; produce an appropriate plan library; and design and implement the rule base. The most important component is the assessment grammar, since it must be understood by external agents such as a pilot and be rich enough to provide concise hypotheses of the world. I.E.

A90-30764
REAL-TIME ADAPTIVE CONTROL OF KNOWLEDGE BASED AVIONICS TASKS
RICHARD COWIN and HAIG F. KRIKORIAN (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 1175-1184. Research supported by Northrop's Artificial Intelligence Independent Research and Development Program. refs
Copyright

Advanced decision-making capabilities are being developed to aid the pilots of the next generation of tactical fighters. Due to the limited processing resources available in an avionics suite, efforts have focused on developing a distributed fault-tolerant software architecture that permits the real-time prioritization and scheduling of these tasks. This paper outlines the design details of an architecture currently under development to meet these performance requirements. The system has been tested with a threat-avoidance system, implemented on a test bed of five internetted LISP workstations, to evaluate overall system capabilities including scheduling, task operations, and data-base accesses. It has a simulation cycle of 50 msec, and synchronization between distributed nodes can be achieved within 2 msec. This system has been evaluated with the current trace capabilities and runs with a peak of 16 task instances active at any time. I.E.

A90-30767
AN INTEGRATED DIAGNOSTICS APPROACH TO EMBEDDED AND FLIGHT-LINE SUPPORT SYSTEMS
ANNE M. STANLEY, JAMES D. SMITH, and KENNETH R. TOLL (Rockwell International Corp., Anaheim, CA) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 1351-1358. refs
Copyright

The current technology of expert systems affords opportunities for improved onboard and offboard diagnostic systems that are a necessity for future avionics and support systems. A proposed architecture and methodology are discussed that address the requirements for such systems. The concepts discussed include real-time expert system issues; diagnostic-system compatibility issues; and considerations for the development, testing, and fielding of such systems. The focus is on fault detection and isolation, including the concepts and implementation of such a system. It is stressed that, in order to achieve the goals of the USAF integrated diagnostics program, emphasis must be placed on providing consistency and compatibility and a support system that complements them. I.E.

A90-30782
THE AUTOMATED SOFTWARE DEVELOPMENT PROJECT AT MCDONNELL AIRCRAFT COMPANY (THE SOFTWARE FACTORY)
SHARILYN A. THORESON (McDonnell Aircraft Co., Saint Louis, MO) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 4. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 1576-1580.
Copyright

The author describes a software engineering environment, the Software Factory, designed specifically for McDonnell Aircraft Company's (MAC's) advanced aircraft projects which must satisfy new requirements for documentation, implementation language, embedded processors, and distributed onboard architectures. The Software Factory is increasing the quality of MAC's avionic software and is increasing the productivity of MAC's avionic software engineers by providing state-of-the-art software development technologies, promoting the use of advanced methodologies, and allowing software managers to understand and control the process through the use of configuration management. The major functional characteristics of the Software Factory, including tools specifically addressing testing and quality assurance, are described. I.E.

A90-30786
CATEGORIZATION AND PERFORMANCE ANALYSIS OF ADVANCED AVIONICS ALGORITHMS ON PARALLEL PROCESSING ARCHITECTURES
C. KEAGLE, R. DELCOCO, J. KURTZ (Westinghouse Electric Corp., Baltimore, MD), A. AGRAWALA (Maryland, University, College Park), and J. WILGUS (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 4. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 1722-1724.
(Contract F33615-88-C-1712)
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Some of the emerging candidate advanced avionics algorithms for next-generation aircraft and missions are discussed. Details of algorithm categorization and architecture classification and categorization are presented. In addition, a methodology for mapping the algorithms into the parallel-processing architectures is developed. In order to determine the algorithm performance on candidate architectures, a task graph is constructed for the critical processing areas, indicating data dependencies, memory accesses, throughputs, data rates, primitives, and timing requirements. Both the primitives and processing architectures are categorized, and a heuristic mapping is performed. For each task graph and primitive, candidate architectures are analyzed in order to determine performance metrics. I.E.

A90-30789
EVALUATION OF SENSOR MANAGEMENT SYSTEMS
PETER L. ROTHMAN and STEPHEN G. BIER (Tau Corp., Long Beach, CA) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 4. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 1747-1752.
Copyright

The authors outline a framework within which evaluation and comparison of sensor management systems should be performed. The four aspects of this framework are: (1) selection of numerical measures of performance (MOPs) which are relevant to the mission goals; (2) determination of the relative importance (weights) of each of these MOPs with respect to the mission goals; (3) definition of benchmark scenarios for evaluating the performance of the sensor management system with respect to these MOPs and mission goals; and (4) comparison of the performance of the sensor management system to the performances of several basic sensor management systems with respect to the benchmark scenarios. I.E.

A90-30793#
THE USE OF NON-DEDICATED REDUNDANCY IN THE AMCAD FAULT TOLERANT CONTROL SYSTEM
DANIEL B. THOMPSON and MICHAEL S. ROTTMAN (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 4. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 1770-1774. refs

The Flight Control Division of the Air Force Flight Dynamics Laboratory has been researching the applicability of fault-tolerant multiprocessor computing architectures for flight/vehicle control. A primary goal is to utilize pools of computing resources with software-mapped redundant tasks. In the present work, the concept of logical redundancy is discussed as applied in the advance multiprocessor control architecture development (AMCAD) conceptual system and in-house laboratory testbed. In addition, an overview of AMCAD is given. I.E.

A90-30796
A COMPUTER-AIDED CONTROL ENGINEERING ENVIRONMENT FOR MULTI-DISCIPLINARY EXPERT-AIDED ANALYSIS AND DESIGN (MEAD)
JAMES H. TAYLOR (GE Control Systems Laboratory, Schenectady, NY) and PHILLIP D. MCKEEHEN (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 4. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 1798-1806. Research supported by Northrop Corp., GE Aircraft Engines, and Aule-Tek, Inc. refs
(Contract F33615-85-C-3611)
Copyright

The MEAD (multidisciplinary expert-aided analysis and design) project involves integrating computer-aided control engineering (CACE) packages under a supervisor that coordinates the use of these packages with a database manager, an expert system, and an advanced user interface. The supervisor is the shell or package integrator for underlying CACE packages and coordinates all activity within the MEAD environment. The database manager keeps track of system models that evolve over time and relates each analysis or design result to the right model instance. The expert system provides expert aiding for clear-cut but complicated procedures that would otherwise involve unnecessary low-level detail. The user interface facilitates access to the CACE package capabilities by users with widely different levels of familiarity with the environment and simplifies the use of the expert system and database manager. These goals are achieved by permitting the user to work in several modalities: a menu/forms-style user interface for basic CACE activity; use of MEAD commands when this mode expedites CACE work compared with the more user-friendly menu/forms mode; use of the core packages' native commands when the exact desired functionality is not conveniently available via MEAD commands; or use of the MEAD macro facility. I.E.

A90-30800
A MICROCOMPUTER-BASED AIRSPACE CONTROL SIMULATION AND PROTOTYPE HUMAN-MACHINE INTERFACE
KENNETH A. TENCH (Analytic Sciences Corp., Reading, MA) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 4. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 1851-1858.
Copyright

ATALARS (automated tactical aircraft launch and recovery system) is a concept for a fully automated air traffic management system intended for post-2000 military service. Part of the ATALARS concept development effort is directed at defining the role of automation in air traffic control and resolving human-automation interface issues. In the ACES (ATALARS concept evaluation simulation), PASCAL is used in order to get the faster real-time performance required. The automation algorithms are a combination of computations and rule-based expert system decisions, also written in PASCAL. The human-machine interface is a prototype of a possible airspace manager or air traffic controller workstation, incorporating color displays, pull-down menus, pop-up information windows, and on-screen control buttons. The interface also allows the user to control the aircraft via commands generated in a 'point-and-shoot' fashion, which is a novel concept for how air traffic controllers might interact with aircraft in the future via data links rather than voice channels. I.E.

A90-30806
SOFTWARE ARCHITECTURE CONCEPTS FOR AVIONICS
J. V. BERK, A. H. MUNTZ, and P. R. STEVENS (Hughes Aircraft

Co., Los Angeles, CA) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 4. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 1900-1905.
Copyright

The authors describe a radar software architecture developed to provide a systematic framework for developing airborne radar software. The software architecture has been successfully applied to a number of major programs, allowing these programs to share reusable software requirements, design, and code. Also discussed are attempts to extend the architecture to accommodate more sophisticated tactical threats and advances in processor and sensor technology. I.E.

A90-30816
COMMONALITY OF MASA MODULES
J. B. KINDER (Support Systems Associates, Inc., Fairborn, OH) IN: NAECON 89; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 22-26, 1989. Volume 4. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 2050-2054. refs
Copyright

The Modular Avionics System Architecture (MASA) program is evaluating the use of technology and design improvement features from the Pave Pillar, VHSIC, and the Joint Integrated Avionics Work Group as retrofits to existing aircraft. The commonality aspects of the MASA program are discussed. The results of commonality are illustrated through a sequencing scenario of the study cases in which later, integrated developments reuse designs or modules from previous systems. The areas for potential savings attributable to commonality are described. It is noted that the reuse benefits of the standard function modules offset the initial advantage of lower unit costs for point designs. I.E.

A90-31108
ALGORITHM FOR SIMULTANEOUS STABILIZATION OF SINGLE-INPUT SYSTEMS VIA DYNAMIC FEEDBACK
DONG-NAN WU, WEI-BING GAO, and MIAN CHEN (Beijing University of Aeronautics and Astronautics, People's Republic of China) International Journal of Control (ISSN 0020-7179), vol. 51, March 1990, p. 631-642. Research supported by the National Natural Science Foundation of the People's Republic of China. refs
Copyright

Using a sufficient algebraic stability criterion for polynomials, an algorithm is deduced for the design of dynamic feedback which simultaneously stabilizes a set of single-input systems. The application of this algorithm to the stabilization problem of an aircraft is also presented. Author

N90-18882*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LOW-ENERGY GAMMA RAY ATTENUATION CHARACTERISTICS OF AVIATION FUELS
JAG J. SINGH, CHIH-PING SHEN (Old Dominion Univ., Norfolk, VA.), and DANNY R. SPRINKLE Washington Mar. 1990 40 p
(NASA-TP-2974; L-16719; NAS 1.60:2974) Avail: NTIS HC A03/MF A01 CSCL 09/2

Am241 (59.5 keV) gamma ray attenuation characteristics were investigated in 270 aviation fuel (Jet A and Jet A-1) samples from 76 airports around the world as a part of world wide study to measure the variability of aviation fuel properties as a function of season and geographical origin. All measurements were made at room temperature which varied from 20 to 27 C. Fuel densities (rho) were measured concurrently with their linear attenuation coefficients (mu), thus providing a measure of mass attenuation coefficient (mu/rho) for the test samples. In 43 fuel samples, rho and mu values were measured at more than one room temperature, thus providing mu/rho values for them at several temperatures. The results were found to be independent of the temperature at which mu and rho values were measured. It is noted that whereas the individual mu and rho values vary considerably from airport to airport as well as season to season, the mu/rho values for all samples are constant at 0.1843 + or - 0.0013 cu cm/gm. This constancy of mu/rho value for aviation fuels is significant since a nuclear fuel quantity gauging system based on low energy gamma ray attenuation will be viable throughout the world. Author

N90-18908# California Univ., Los Angeles. Dept. of Electrical Engineering.
CONTROL AND STABILIZATION OF LINEAR AND NONLINEAR DISTRIBUTED SYSTEMS Final Technical Report, 1 Apr. 1986 - 31 Dec. 1988
N. LEVAN and P. K. C. WANG 31 Dec. 1988 20 p Presented at the 1st International Conference in Industrial Applied Mathematics Submitted for publication
(Contract AF-AFOSR-0132-86; AF PROJ. 2304)
(AD-A216446; AFOSR-89-1717TR) Avail: NTIS HC A02/MF A01 CSCL 12/2

The results are summarized of a study on the control and stabilization of linear and nonlinear distributed systems. The specific areas of study consists of: (1) stability enhancement of distributed systems describable by abstract linear evolution equations, (2) a translation invariant approach to stability and stabilizability, (3) stabilizability of bilinear systems, (4) application of computer vision in static shape estimation, control, and failure detection in elastic systems, and (5) stabilization and control of distributed systems with application to aeroelastic systems with extendible lifting surfaces. The main objective is to develop applicable mathematical theories and at the same time study specific systems arising from realistic aerospace applications. GRA

N90-18920# University of Southern California, Los Angeles. Dept. of Electrical Engineering Systems.
PRACTICAL METHODS FOR ROBUST MULTIVARIABLE CONTROL Final Report, 1 Aug. 1988 - 31 Jul. 1989
MICHAEL G. SAFONOV and EDMOND A. JONCKHEERE 12 Oct. 1989 25 p
(Contract AF-AFOSR-0282-88; AF PROJ. 2304)
(AD-A216937; AFOSR-89-1700TR) Avail: NTIS HC A02/MF A01 CSCL 01/2

The design of supermaneuverable fighter aircraft, high precision space-born optical tracking systems and transatmospheric hypervelocity vehicles will pose significant challenges to modern control system design theory. The theme of the research has been making modern control theory work. The product of the research was theory, algorithms and software applicable to multivariable feedback control problems in which there are design constraints requiring robust attainment of stability and control performance objectives in the face of both structured and unstructured uncertainty. GRA

N90-19756# National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials/Informatics Div.
COCOMAT: A COMPUTER AIDED ENGINEERING (CAE) SYSTEM FOR COMPOSITE STRUCTURES DESIGN
H. J. W. M. KOELMAN and H. W. VEERBEEK 26 Nov. 1987 18 p Presented at the Computer Aided Design in Composite Material Technology CADCOMP 1988, Southampton, England, 13-15 Apr. 1988 Previously announced in IAA as A89-19981
(Contract NIVR-03506N)
(NLR-MP-87078-U; ETN-89-94047) Avail: NTIS HC A03/MF A01

Capabilities of a system called COCOMAT are given as an example of a CAE system for assistance during the preliminary design phase of a structure. The features of the system are illustrated with an example of the design of a post-buckled, hat stiffened, composite wing panel. ESA

16

PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

A90-27978*# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.).
ROTOR BLADE-VORTEX INTERACTION IMPULSIVE NOISE SOURCE LOCALIZATION
W. R. SPLETTSTOESSER, K. J. SCHULTZ (DLR, Brunswick, Federal Republic of Germany), and RUTH M. MARTIN (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 28, April 1990, p. 593-600. Previously cited in issue 04, p. 571, Accession no. A88-16580. refs
Copyright

A90-28158* Continuum Dynamics, Inc., Princeton, NJ.
HIGH RESOLUTION FLOW FIELD PREDICTION FOR TAIL ROTOR AEROACOUSTICS
TODD R. QUACKENBUSH (Continuum Dynamics, Inc., Princeton, NJ) and DONALD B. BLISS (Duke University, Durham, NC) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 99-114. refs
(Contract NAS1-18607)
Copyright

The prediction of tail rotor noise due to the impingement of the main rotor wake poses a significant challenge to current analysis methods in rotorcraft aeroacoustics. This paper describes the development of a new treatment of the tail rotor aerodynamic environment that permits highly accurate resolution of the incident flow field with modest computational effort relative to alternative models. The new approach incorporates an advanced full-span free wake model of the main rotor in a scheme which reconstructs high-resolution flow solutions from preliminary, computationally inexpensive simulations with coarse resolution. The heart of the approach is a novel method for using local velocity correction terms to capture the steep velocity gradients characteristic of the vortex-dominated incident flow. Sample calculations have been undertaken to examine the principal types of interactions between the tail rotor and the main rotor wake and to examine the performance of the new method. The results of these sample problems confirm the success of this approach in capturing the high-resolution flows necessary for analysis of rotor-wake/rotor interactions with dramatically reduced computational cost. Computations of radiated sound are also carried out that explore the role of various portions of the main rotor wake in generating tail rotor noise. Author

A90-28159* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
PREDICTION AND MEASUREMENT OF LOW-FREQUENCY HARMONIC NOISE OF A HOVERING MODEL HELICOPTER ROTOR
H. R. AGGARAWAL (Helicopter Aerodynamics and Noise, Mountain View, CA), F. H. SCHMITZ (NASA, Ames Research Center, Moffett Field, CA), and D. A. BOXWELL (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 115-126. refs
Copyright

Far-field acoustic data for a model helicopter rotor have been gathered in a large open-jet, acoustically treated wind tunnel with the rotor operating in hover and out of ground-effect. The four-bladed Boeing 360 model rotor with advanced airfoils, planform, and tip shape was run over a range of conditions typical of today's modern helicopter main rotor. Near in-plane acoustic measurements were compared with two independent implementations of classical linear theory. Measured steady thrust and torque were used together with a free-wake analysis (to predict the thrust and drag distributions along the rotor radius) as input to this first-principles theoretical approach. Good agreement between theory and experiment was shown for both amplitude and phase for measurements made in those positions that minimized distortion of the radiated acoustic signature at low-frequencies. Author

A90-28160* Sikorsky Aircraft, Stratford, CT.
AEROACOUSTIC FLOWFIELD AND ACOUSTICS OF A MODEL HELICOPTER TAIL ROTOR AT HIGH ADVANCE RATIO
RAJARAMA K. SHENOY (Sikorsky Aircraft, Stratford, CT) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 127-139. refs
(Contract NAS1-17146)
Copyright

Some results, relevant to rotorcraft noise generation process at high advance ratio, are presented in this paper from schlieren flow visualization and acoustic tests of a model tail rotor. The measured in-plane noise trends are consistent with the growth of the tip supersonic region seen in the schlieren visuals. Schlieren flow visuals reveal a propagating pressure wave in the second quadrant. Simultaneously measured acoustic data and the results of two-dimensional transonic Blade-Vortex Interaction analysis code ATRAN-2 indicate that this pressure wave is attributable to BVI activity in the first quadrant. This paper establishes that the transonic Blade-Vortex Interactions contribute to noise at high advance ratio level flight conditions. Author

A90-28161* Planning Research Corp., Hampton, VA.
THE PREDICTION OF THE NOISE GENERATING MECHANISMS OF AN AEROSPATIALE 365N-1 DAUPHIN HELICOPTER
DONALD S. WEIR (Planning Research Corp., Hampton, VA) and ROBERT A. GOLUB (NASA, Langley Research Center, Hampton, VA) IN: AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, p. 153-166. refs
Copyright

The National Aeronautics and Space Administration (NASA) is engaged in a joint program with the U.S. helicopter industry to develop a full system helicopter noise prediction computer program called ROTONET. The long term goal of the system is to achieve the ability to predict a helicopter noise signature from the basic input of helicopter geometry and operating condition data. It is being developed in phases, with each phase representing an increase in sophistication. NASA is also performing a series of flight tests to provide a validation data base for the ROTONET System. A joint NASA/U.S. Army test of an Aerospatiale 365N-1 Dauphin helicopter is an element of the series. A comprehensive data base of spectra, noise level time histories, and effective perceived noise levels, incorporating actual meteorological conditions and helicopter dynamics, was produced from this test. Comparisons are made of predictions of the individual source generating mechanisms from the ROTONET System with data from the Aerospatiale 365N-1 Dauphin flyover test. EPNL and noise level time history comparisons demonstrate the overall capabilities of the prediction system. Graphs of 1/3 octave band noise spectra of experimental data and prediction allow identification of the dominant noise prediction mechanisms for various frequencies, directivity angles, and operating conditions. Author

A90-29402#
STRUCTURE-BORNE NOISE TRANSMISSION IN CYLINDRICAL ENCLOSURES DUE TO RANDOM EXCITATION
DIMITRI A. BOFILIOS (Integrated Aerospace Science Corp., San Diego, CA and Athens, Greece) and CONSTANTINOS S. LYRINTZIS (San Diego State University, CA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and

Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1847-1856. Research supported by San Diego State University. refs
(AIAA PAPER 90-0990) Copyright

This paper presents an analytical study of structureborne noise transmission of finite double-wall-laminated fiber-reinforced cylindrical cnclosures due to stochastic excitation. The stochastic excitations are either uniform random pressures or random point loads with specified spectral densities. The theoretical solutions of the governing acoustic-structural equations are obtained via modal decomposition and a Galerkin-like approach. Numerical results indicative of the effects of acoustic and structural variations are offered. Author

N90-18999 National Physical Lab., Teddington (England). Div. of Radiation Science and Acoustics.
NOISE LEVELS FROM A VSTOL AIRCRAFT MEASURED AT GROUND LEVEL AND AT 1.2 M ABOVE THE GROUND
R. C. PAYNE Oct. 1989 42 p
(NPL-RSA(EXT)-009; ISSN-0955-9655; ETN-90-96287) Copyright Avail: National Physical Lab., Teddington, Middlesex, TW11 OLW, England

During a series of aircraft flight tests using a British Aerospace Sea Harrier (FRS Mk1) noise measurements were obtained using microphones close to the ground plane and at a height of 1.2 m. Substantial differences from ground level to 1.2 m were observed, in measurements of perceived noise level and effective perceived noise level. The differences were found to be dependent on ground cover and flight maneuver and for a microphone located 1.2 m above a grass surface a dependence on precise microphone positioning was observed. The ground-plane microphones produced noise levels which closely approximated pressure-doubled values. A procedure for correcting 1/3 octave band sound pressure levels measured 1.2 m above the ground, to obtain pressure-doubled levels is examined. It is concluded that to avoid significant variations in measured noise levels, measurements should be made using a ground-plane microphone arrangement. ESA

N90-19820# Sandia National Labs., Albuquerque, NM.
SANDIA NATIONAL LABORATORIES' NEW HIGH LEVEL ACOUSTIC TEST FACILITY
JONATHAN D. ROGERS and DAVID M. HENDRICK 1989 7 p
Presented at the 36th Institute of Environmental Science Annual Technology Meeting, New Orleans, LA, 23-27 Apr. 1990
(Contract DE-AC04-76DP-00789)
(DE90-006810; SAND-89-2867C; CONF-900479-1) Avail: NTIS HC A02/MF A01

A high intensity acoustic test facility has been designed and is under construction at Sandia National Laboratories in Albuquerque, NM. The chamber is designed to provide an acoustic environment of 154dB (re 20 microPa) overall sound pressure level over the bandwidth of 50 Hz to 10,000 Hz. The chamber has a volume of 16,000 cubic feet with interior dimensions of 21.6 ft x 24.6 ft x 30 ft. The construction of the chamber should be complete by the summer of 1990. The design goals and constraints of the facility are discussed. The construction characteristics are discussed in detail, as are the acoustic performance design characteristics. The authors hope that this work will help others in designing acoustic chambers. DOE

N90-19821*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A NOTE ON AN ACOUSTIC RESPONSE DURING AN ENGINE NACELLE FLIGHT EXPERIMENT
JAMES A. SCHOENSTER Jan. 1990 18 p
(NASA-TM-102585; NAS 1.15:102585) Avail: NTIS HC A03/MF A01 CSCL 20/1

During a flight test study of the noise effects on laminar flow on the outside surface of a simulated engine nacelle, an intense acoustic response was observed. The aircraft speed at which this signal occurred and the frequency content of the signal fell within the test conditions of the experiment and had to be eliminated prior to continuing. The signal was identified as an aerodynamic excitation of an acoustic mode in the simulated by-pass duct of the nacelle. By modifying the trailing edges of the support struts of the nacelle, the aerodynamic excitation was changed enough to eliminate the resonant response of the offending duct modes, eliminating the unwanted acoustic problem. Author

N90-19842# Aerospace Medical Research Labs., Wright-Patterson AFB, OH.
A NEW METHOD FOR MEASURING THE TRANSMISSIVITY OF AIRCRAFT TRANSPARENCIES Final Report, Oct. 1988 - Sep. 1989
HARRY L. TASK and HAROLD S. MERKEL Dec. 1989 27 p
(Contract AF PROJ. 7184)
(AD-A216953; AAMRL-TR-89-044) Avail: NTIS HC A03/MF A01 CSCL 20/6

Transmissivity is a measurement of the relative amount of light transmitted through a part. It is an important optical parameter for aircraft transparencies, since it determines the apparent brightness of the objects observed outside the cockpit. Because visual parameters such as acuity, contrast threshold, and color perception vary with brightness at low luminance values, transmissivity can have a direct effect on vision. The transmissivity of aircraft transparencies is currently measured following the American Standard for Testing and Materials Test Method D-1003. This method, originally intended for the measurement of small, thin, flat parts, has several shortcomings for measuring aircraft transparencies. A new method for measuring transmissivity, which overcomes the shortcomings of D-1003, is described. The precision of both methods was determined in laboratory tests; the results of these tests are presented. The new test method, in addition to its application advantages, is slightly more precise than ASTM D-1003. GRA

N90-19852# Maryland Univ., College Park. Div. of Mathematical and Physical Engineering.
NONLINEAR MECHANICS OF UNSTABLE PLASMAS AS RELATED TO HIGH ALTITUDE AERODYNAMICS Final Report, 30 Sep. 1976 - 31 Dec. 1980
H. LASHINSKY, J. SILVERMAN, and R. F. ELLIS May 1981 9 p
(Contract AF-AFOSR-3129-76; AF PROJ. 2307)
(AD-A215126) Avail: NTIS HC A02/MF A01

In the initial stages, research was concerned with the application and experimental techniques which were well known in lumped-parameter systems. Particular emphasis was given to plasma instabilities, nonlinear effects leading to heating of plasma, and turbulence phenomena which affect hypersonic plasma flow. The work consisted of a theoretical program supported by experimental work in a low-temperature plasma device known as a Q-machine. A van der Pol equation was modified, a new equation (Lashinsky-Cap) was derived to describe various periodic instabilities typical of high-speed flow in fluids and plasmas, and a new form of the Mathieu equation developed which describes nonlinear effects in the degenerate parametric excitation of plasma waves. Author

17

SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

N90-19060# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
CALENDAR OF SELECTED AERONAUTICAL AND SPACE MEETINGS

Dec. 1989 117 p In ENGLISH and FRENCH
(AGARD-CAL-90/1; ISBN-92-835-0536-0) Copyright Avail: NTIS HC A06/MF A01; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Three kinds of events are covered by this calendar: technical meetings, conferences, and symposia; exhibitions and technical displays covering the same field of interest; and educational courses given by specialized institutions. For each meeting, exhibition, or course, the following information is given, where known: reference number, data, location, title and sponsor, keywords, and contact code for inquiries. Included are a keyword index, country codes, and a list of organizations. Author

19

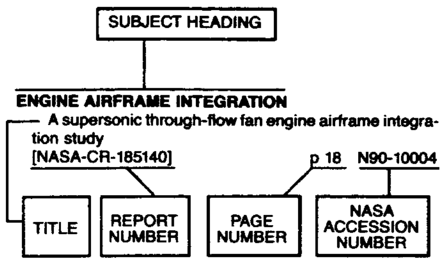
GENERAL

N90-19189# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Cologne (Germany, F.R.).
ACTIVITIES REPORT IN GERMAN AEROSPACE Annual Report, 1988 - 1989 [JAHRESBERICHT 1988/89]
Sep. 1989 82 p In GERMAN Original contains color illustrations
(ISSN-0070-3966; ETN-90-96280) Avail: NTIS HC A05/MF A01

The atmospheric and space flight research carried out by the DLR over the course of 1988 and 1989 is described. An intensive helicopter design project is described. New quieter helicopter blades are developed. Better aircraft crash resistance is investigated. Earth imaging from low earth orbits is discussed. The synthetic aperture radar carried aboard the Space Shuttle is described. Reduced gravity training of European astronauts is discussed, as are technological spinoffs of DLR space research. ESA

SUBJECT INDEX

Typical Subject Index Listing



The subject heading is a key to the subject content of the document. The title is used to provide a description of the subject matter. When the title is insufficiently descriptive of document content, a title extension is added, separated from the title by three hyphens. The (NASA or AIAA) accession number and the page number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document. Under any one subject heading, the accession numbers are arranged in sequence with the AIAA accession numbers appearing first.

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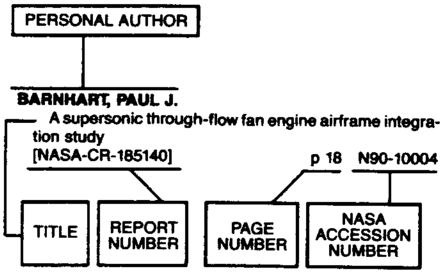
PERSONAL AUTHOR INDEX

Typical Personal Author Index Listing



Listings in this index are arranged alphabetically by personal author. The title of the document provides the user with a brief description of the subject matter. The report number helps to indicate the type of document listed (e.g., NASA report, translation, NASA contractor report). The page and accession numbers are located beneath and to the right of the title. Under any one author's name the accession numbers are arranged in sequence with the AIAA accession numbers appearing first.

A

B

I

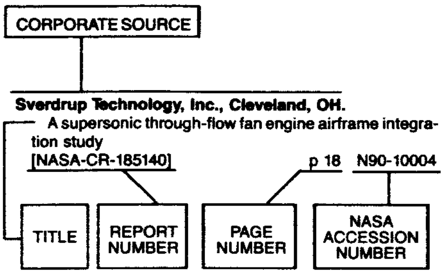
J

K

L

M

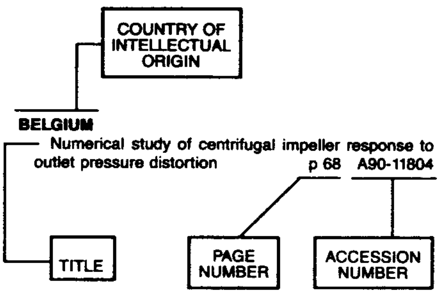
Typical Corporate Source Index Listing



Listings in this index are arranged alphabetically by corporate source. The title of the document is used to provide a brief description of the subject matter. The page number and the accession number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document.

FOREIGN TECHNOLOGY INDEX

Typical Foreign Technology Index Listing



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FOREIGN

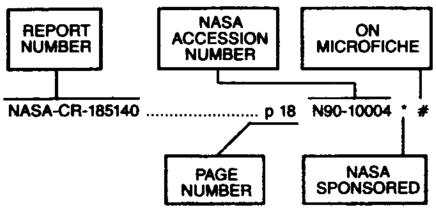
Typical Contract Number Index Listing

NAS3-23051 .... p 52 N90-10045

CONTRACT NUMBER | PAGE NUMBER | NASA ACCESSION NUMBER

Listings in this index are arranged alphanumerically by contract number. Under each contract number, the accession numbers denoting documents that have been produced as a result of research done under the contract are arranged in ascending order with the AIAA accession numbers appearing first. The accession number denotes the number by which the citation is identified in the abstract section. Preceding the accession number is the page number on which the citation may be found.

Typical Report Number Index Listing



Listings in this index are arranged alphanumerically by report number. The page number indicates the page on which the citation is located. The accession number denotes the number by which the citation is identified. An asterisk (*) indicates that the item is a NASA report. A pound sign (#) indicates that the item is available on microfiche.

REPORT

Typical Accession Number Index Listing

N90-10004 * # p 18

NASA ACCESSION NUMBER | NASA SPONSORED | ON MICROFICHE | PAGE NUMBER

Listings in this index are arranged alphanumerically by accession number. The page number listed to the right indicates the page on which the citation is located. An asterisk (*) indicates that the item is a NASA report. A pound sign (#) indicates that the item is available on microfiche.

A90-27645		p 457
A90-27678		p 444
A90-27679		p 440
A90-27681		p 440
A90-27781		p 402
A90-27875		p 402
A90-27922		p 402
A90-27923		p 403
A90-27924		p 403
A90-27925		p 403
A90-27947		p 383
A90-27951		p 444
A90-27953		p 435
A90-27959	#	p 421
A90-27962	#	p 421
A90-27963	#	p 421
A90-27966	* #	p 383
A90-27972	#	p 421
A90-27975		p 405
A90-27976	#	p 383
A90-27977	* #	p 384
A90-27978	* #	p 463
A90-27979	#	p 384
A90-27985	* #	p 384
A90-27986	#	p 400
A90-27992	#	p 444
A90-27993	* #	p 405
A90-27999	#	p 444
A90-28003	#	p 441
A90-28006	#	p 445
A90-28007	#	p 429
A90-28135	#	p 445
A90-28137	*	p 445
A90-28151		p 381
A90-28152		p 406
A90-28153		p 406
A90-28154		p 406
A90-28155		p 406
A90-28156		p 435
A90-28157		p 429
A90-28158	*	p 463
A90-28159	*	p 463
A90-28160	*	p 463
A90-28161	*	p 463
A90-28162		p 445
A90-28163		p 381
A90-28164		p 381
A90-28165		p 445
A90-28166		p 406
A90-28167	*	p 406
A90-28168		p 421
A90-28169		p 381
A90-28170		p 406
A90-28171		p 384
A90-28172		p 384
A90-28173		p 407
A90-28174		p 384
A90-28175	*	p 407
A90-28176		p 384
A90-28177		p 422
A90-28178		p 422
A90-28179	*	p 400
A90-28180	*	p 400
A90-28181		p 422
A90-28182	*	p 400
A90-28183		p 422
A90-28184	*	p 457
A90-28187		p 445
A90-28188		p 407
A90-28189		p 441
A90-28191		p 441
A90-28192		p 441
A90-28193		p 441
A90-28194	*	p 384
A90-28195	*	p 385
A90-28196	* #	p 407
A90-28197	*	p 385
A90-28198		p 385
A90-28199		p 422
A90-28200		p 429
A90-28201	*	p 429
A90-28202	*	p 429
A90-28203		p 407
A90-28204		p 430
A90-28207		p 422
A90-28209		p 417
A90-28211		p 407
A90-28212		p 408
A90-28213		p 408
A90-28214		p 408
A90-28215		p 408
A90-28216	*	p 430
A90-28217		p 417
A90-28218		p 417
A90-28219	*	p 403
A90-28220		p 430
A90-28221		p 417
A90-28223		p 408
A90-28225		p 430
A90-28226		p 408
A90-28227		p 430
A90-28228	*	p 385
A90-28229		p 408
A90-28230		p 409
A90-28231		p 441
A90-28232		p 409
A90-28233		p 409
A90-28234		p 445
A90-28235		p 409
A90-28236		p 409
A90-28238	*	p 409
A90-28239		p 410
A90-28240	*	p 410
A90-28241		p 385
A90-28242		p 381
A90-28243		p 385
A90-28244		p 410
A90-28252		p 386
A90-28254	#	p 435
A90-28255	* #	p 436
A90-28256		p 436
A90-28257		p 436
A90-28258		p 446
A90-28259		p 446
A90-28260	*	p 436
A90-28262		p 446
A90-28263		p 446
A90-28264		p 446
A90-28268	*	p 446
A90-28271		p 447
A90-28272		p 423
A90-28273		p 447
A90-28278	*	p 447
A90-28279		p 447
A90-28281	#	p 436
A90-28282		p 436
A90-28283		p 447
A90-28284		p 447
A90-28287		p 436
A90-28288		p 437
A90-28289	* #	p 437
A90-28291		p 417
A90-28292		p 437
A90-28293		p 437
A90-28294		p 437
A90-28295	* #	p 448
A90-28296		p 438
A90-28300		p 438
A90-28302		p 438
A90-28305		p 438
A90-28306	* #	p 448
A90-28310		p 457
A90-28319		p 381
A90-28321		p 457
A90-28323		p 457
A90-28330		p 457
A90-28337		p 448
A90-28342		p 458
A90-28343		p 448
A90-28348		p 382
A90-28407		p 417
A90-28552		p 386
A90-28555	*	p 386
A90-28571	*	p 423
A90-28582		p 455
A90-28612		p 456
A90-28613		p 456
A90-28617		p 456
A90-28620		p 456
A90-28625		p 456
A90-28825		p 448
A90-28829		p 458
A90-28839		p 403
A90-28849		p 418
A90-28850		p 418
A90-28852		p 458
A90-28860		p 458
A90-28874		p 418
A90-28895		p 418
A90-28979		p 386
A90-28980		p 386
A90-28981		p 386
A90-28985		p 386
A90-28987		p 387
A90-28988		p 387
A90-28989		p 387
A90-28990		p 387
A90-28991		p 387
A90-28992		p 387
A90-28993		p 410
A90-28994		p 448
A90-29001		p 448
A90-29003		p 387
A90-29004		p 387
A90-29005		p 388
A90-29006		p 388
A90-29012		p 388
A90-29147		p 449
A90-29181		p 388
A90-29182		p 388
A90-29183		p 388
A90-29184		p 388
A90-29185		p 438
A90-29187		p 430
A90-29188		p 410
A90-29191		p 410
A90-29194		p 388
A90-29226		p 449
A90-29237	* #	p 410
A90-29238	#	p 411
A90-29239	#	p 411
A90-29240	#	p 411
A90-29241	#	p 438
A90-29275	#	p 442
A90-29276	#	p 449
A90-29286	* #	p 449
A90-29293	* #	p 458
A90-29305	* #	p 411
A90-29340	#	p 449
A90-29359		p 449
A90-29360	#	p 389
A90-29361	#	p 389
A90-29362	* #	p 389
A90-29363	* #	p 389
A90-29364	* #	p 389
A90-29365	#	p 390
A90-29366	* #	p 390
A90-29367	#	p 390
A90-29368	#	p 390
A90-29369	* #	p 390
A90-29370	#	p 390
A90-29371	* #	p 391
A90-29372	* #	p 450
A90-29373	#	p 450
A90-29374	* #	p 391
A90-29375	#	p 391
A90-29376	* #	p 391
A90-29377	* #	p 391
A90-29378	#	p 392
A90-29379	#	p 450
A90-29380	* #	p 450
A90-29381	* #	p 411
A90-29382	* #	p 430
A90-29383	#	p 392
A90-29384	#	p 411
A90-29385	#	p 431
A90-29386	* #	p 412
A90-29387	* #	p 392
A90-29388	#	p 392
A90-29389	#	p 412
A90-29390	#	p 392
A90-29391	#	p 392
A90-29392	* #	p 393
A90-29393	* #	p 393
A90-29394	#	p 412
A90-29395	#	p 412
A90-29396	#	p 450
A90-29397	#	p 393
A90-29399	#	p 451
A90-29400	#	p 451
A90-29402	#	p 463
A90-29405	#	p 412
A90-29429	* #	p 451
A90-29467	* #	p 412
A90-29492	#	p 442
A90-29591		p 393
A90-29598	* #	p 382
A90-29637		p 382
A90-29638		p 442
A90-29641		p 382
A90-29643		p 442
A90-29654		p 451
A90-29655		p 403
A90-29661		p 413
A90-29686	* #	p 440
A90-29687	#	p 393
A90-29695	* #	p 393
A90-29704	*	p 442
A90-29707		p 442
A90-29803		p 400
A90-29825		p 443
A90-29866		p 451
A90-29880		p 423
A90-29881		p 443
A90-29882		p 393
A90-29883	#	p 394
A90-29884	#	p 394
A90-29885	#	p 394
A90-29886	* #	p 394
A90-29887	* #	p 394
A90-29888	#	p 394
A90-29889	#	p 394
A90-29890		p 413
A90-29891		p 451
A90-29892		p 382
A90-29893		p 451
A90-29897		p 458
A90-29904	#	p 423
A90-29906	#	p 423
A90-29908	#	p 423
A90-29911	#	p 451
A90-29917	#	p 423
A90-29918	#	p 424
A90-29919	#	p 424
A90-29921		p 382
A90-29922		p 424
A90-29924		p 438
A90-29943		p 418
A90-29946		p 424
A90-29977		p 452
A90-30103		p 431
A90-30105		p 431
A90-30107	*	p 413
A90-30114		p 382
A90-30115		p 452
A90-30117		p 413
A90-30118		p 413
A90-30119		p 413
A90-30222		p 413
A90-30226		p 458
A90-30230	#	p 459
A90-30236	#	p 459
A90-30238	#	p 418
A90-30249	#	p 459
A90-30251		p 439
A90-30264	* #	p 394
A90-30268		p 452
A90-30275		p 414
A90-30334		p 395
A90-30339		p 395
A90-30342		p 395
A90-30344		p 395
A90-30479		p 443
A90-30587		p 400
A90-30681		p 418
A90-30682	#	p 419
A90-30688		p 403
A90-30689	#	p 459
A90-30693		p 404
A90-30694		p 419
A90-30695		p 404
A90-30699		p 424
A90-30703		p 431
A90-30704	#	p 431
A90-30705	#	p 431
A90-30706	* #	p 452
A90-30707	#	p 432
A90-30708		p 432
A90-30710		p 432
A90-30711		p 452
A90-30712		p 424
A90-30713	#	p 432
A90-30714		p 432
A90-30715	#	p 432
A90-30716	#	p 439
A90-30717		p 433
A90-30719	*	p 459
A90-30723		p 419
A90-30724		p 419

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